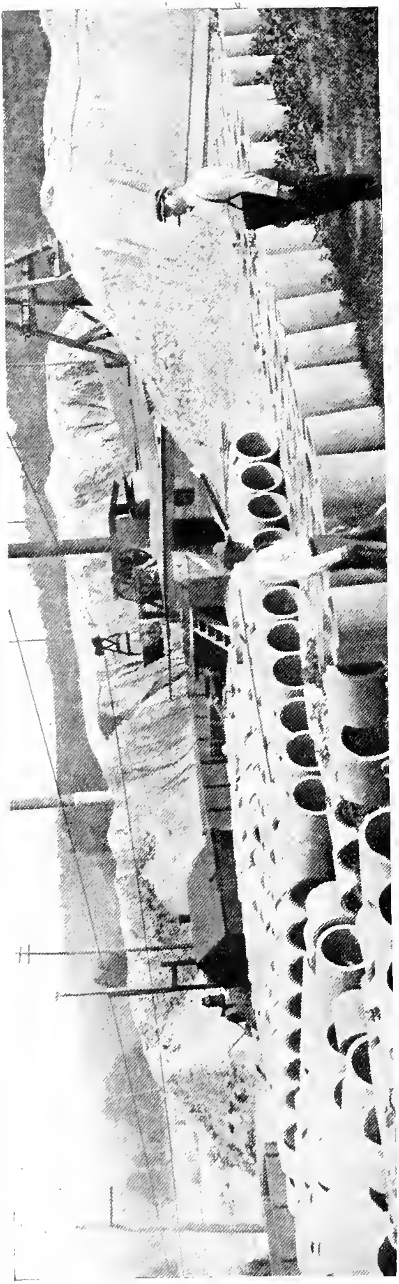

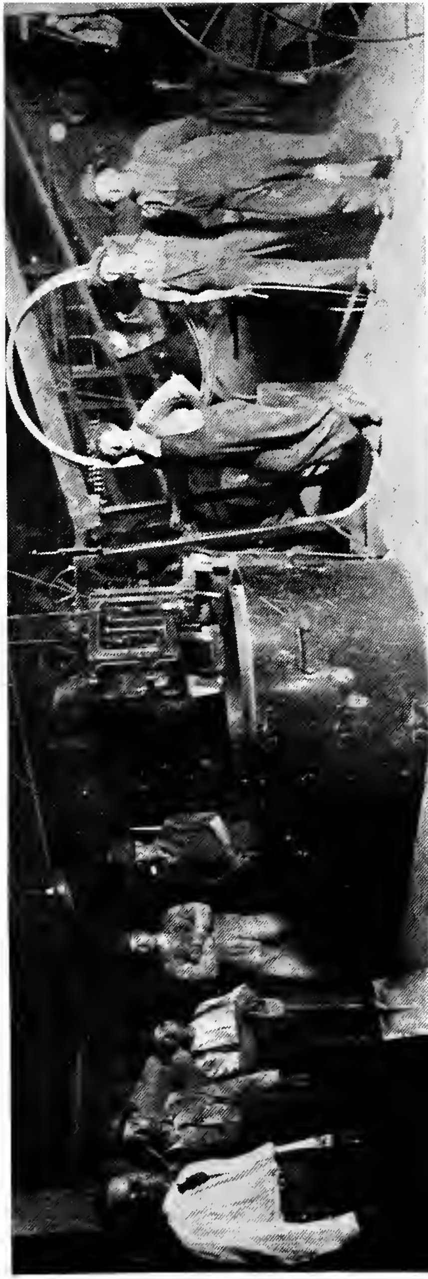

CEMENT PIPE AND TILE

ADVANTAGES OF CEMENT FOR PIPE AND TILE, METHODS OF MANUFACTURE, TESTS, COST, ETC.

(SECOND EDITION)

BY

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PREFACE TO SECOND EDITION.

The earlier edition of this book was written less than three years ago; and yet the present volume is as different from it as one could well imagine. This wide difference is but proof of the rapid development which has taken place in the industry in the intervening time, and is, it would seem, sufficient justification for this new edition.

The wish of the writer is that it may merit the many kind words which have been spoken and written concerning its predecessor, and that it may be a real help in the upbuilding of what he believes is destined to be one of the most important lines of endeavor in the use of cement.

This book is not intended to be the final word on the subject, for the writer believes that succeeding years will show many important developments which will require subsequent editions. The invitation is therefore extended, as before, to all who are interested in the subject to send in any material which they believe would be of interest.

That this is, as before, very largely a compilation, goes without saying. While the writer has probably visited as many pipe and tile plants as any other one person, he has also drawn freely on other sources of information, which he wishes here to acknowledge.

It is believed that the new form into which the matter has been cast will make it much more easy of access. The aim has been to bring together in one place, as far as possible, all matter relating to each phase of the industry. They are so inter-related, however, that this has not been possible in every case; but it is hoped that the side headings and index will assist the reader in developing to its full extent the information which the book contains.

E. S. H.

Chicago, December 1, 1911.

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Cement Pipe and Tile

CHAPTER I.

INTRODUCTORY.

It is a fact of no little historical interest, as well as of considerable economic importance, that the period of rapid development in the use of cement has been coincident with the widespread awakening of interest in matters of irrigation and drainage.

In the early settlement of our country the farms were located on what were considered the most desirable tracts, determined by accessibility, natural water supply, and the fertility of the soil. As civilization extended westward the homeseeker selected the rolling prairie that needed little or no drainage, so that the swamps and overflowed lands were passed by, and only recently has an imperative demand arisen for their reclamation. As the pioneer went still farther west he passed by the great arid tracts, finding sufficient unoccupied land of abundant fertility for his needs.

But the naturally desirable farming land of the country is now practically all under cultivation or held in possession by speculators, and it has been necessary to devise means of reducing the swamp and arid tracts to a point where they can be made to serve as the dwelling places and the support of our rapidly increasing population. It is safe to say that much of this work which has already been accomplished would have been well nigh impossible without the aid of cement. This "universal binder" has allowed of the utilization of large quantities of local materials, and has adapted itself to inexpensive, portable and easily mastered methods of manufacture.

The drain tile industry has naturally grown faster than

any other branch of this business. The manufacture of cement drain tile by power machinery was first begun in a small factory in Iowa in 1905. Since that time, according to Mr. Charles E. Sims, secretary of the Interstate Cement Tile Manufacturers' Association, in an address before the 1911 convention of the Northwestern Cement Products Association, 372 factories have been established, with an output conservatively estimated at 150,000,000 feet of four-inch to twelve-inch sizes. Allowing 15,000 tile to drain 160 acres, this quantity of tile would drain over 9,900 quarter-sections of wet land. Averaging the size of these tile at six-inch diameter, and their sale value at $33.33 per thousand feet, the total value of the present annual production is $5,000,000. To this production must be added a further estimate of 1,200,000 feet of the larger sizes of tile—14-inch to 36-inch diameters—having a value of $300,000. The total value, then, of the power-made cement drain tile, says Mr. Sims, has increased from nothing in 1905 to the value of $5,300,000 per annum—a rate of growth surprising even to those most intimately acquainted with this new industry. The 372 plants he shows to be distributed as follows:

State	No. of Factories	Annual Production (feet)
Iowa	101	40,400,000
Illinois	59	23,600,000
Ohio	57	22,800,000
Indiana	51	20,400,000
Minnesota	26	10,400,000
Michigan	14	5,600,000
Missouri	10	4,000,000
Colorado	8	3,200,000
Arkansas	6	2,400,000
Nebraska	5	2,000,000
South Dakota	4	1,600,000
Mississippi	3	1,200,000
Other States	21	8,400,000
Canada	7	2,800,000
Total	372	148,800,000

From this it will be seen that the cement tile business has grown into a fairly well developed manufacturing and merchandising industry.

Cement pipe for irrigation work has been given an impetus by the immense amount of reclamation work done by the government and by private companies and individuals, much of which could scarcely have been undertaken but for the possibilities of cement. Each project, however, is to a large extent an individual problem, making this line of work an engineering proposition, and less adapted to reduction to manufacture and sale as a staple article of commerce.

The period of development in the application of cement to human needs has also seen the extension of sewer systems to serve by far the larger part of our urban population. Cement has already worked into this field to a considerable extent, and the number of machines for the manufacture of cement sewer pipe which are just now coming onto the market would seem to indicate that the development along this line is to follow largely the growth of the drain tile industry. From present indications the writer feels warranted in predicting that this will be the next most phenomenal development with which concrete is connected.

CHAPTER II.

Advantages of Cement for Pipe and Tile.

Cement has many advantages for the manufacture of these products with which every one connected with the industry should become familiar.

Improves With Age. That concrete in its initial stages improves with age is a fact well recognized even by the most casual observer. A few hours after it has been molded, it has set so hard that its form and shape cannot be changed. No one claims, however, that at this point it is ready for use. The process of crystallization has but just commenced. This process is carried on under certain favorable conditions for a few days and the product is then allowed to lie for a number of more days to attain strength. The thirty or forty days after which pipe is removed from the yard is, however, simply an arbitrary limit set, below which it must not be used. This does not mean that the process of growth going on in the tile has ceased. This process, as is well known to close students of the subject, goes on almost indefinitely, and as it progresses, the more compact and strong does the mass become.

If one goes into the laboratory at a cement plant, he will find stored away on shelves, briquettes of cement immersed in water or under other conditions, which are being kept for a term of years in order that the long process of crystallization may be carefully studied. Tests made upon these will show an increase of strength from year to year.

It is not, therefore, too much to say that one of the greatest advantages of cement pipe is the fact that it increases in strength with the lapse of time. From the very nature of the case, it is kept almost constantly moist,

the necessary amount of water for crystallization thus being supplied.

With clay products, on the other hand, it is a well known fact that they are at their best when they first come from the kiln. In the process of burning, the curing of the tile has been completed for all time. It comes from the kiln a lifeless thing, ready to be attacked by outside conditions the moment it reaches the storage yard. If the burning in the kiln has been imperfect, the tile must remain imperfectly cured. Cement tile, however, even though it may have been improperly made and cured in the first place, has the power of life within itself, so that even after it is laid, the process of acquiring strength and durability will be carried on.

Uniformity of Shape. The uniformity of shape of cement pipe is one of their strong recommendations. They come from the molds perfectly round, true on the ends, and without imperfections in shape of any kind. This advantage of cement tile is most frequently spoken of by men who lay them, and their preference is always for this class of tile. Clay tile, in the process of handling in the yards, handling in the kilns, burning, etc., are apt to get very much out of shape. They lose their true round section, are apt to be bent from the straight line, and the ends are very often imperfect. On this account, the tilers have to take particular care in laying them, often turning them over several times to make them fit one to another. Each cement tile, however, is a perfect cylinder. The same fact has also been noted by ditchers who use a mechanical ditcher which lays the tile automatically. Cement tile go through the machine with little or no trouble, while clay tile have to be watched, and at best are very apt to clog the machine.

Small Investment Required. Another advantage of cement pipe is that they can be manufactured at a large number of different points, thus eliminating to a very large degree the item of transportation. A cement tile plant requires comparatively little equipment, and such equipment as is required is standard, readily secured and

easily operated. The larger part of the work can be done by such common labor as can be found in any community. The only raw material which has to be secured locally is a supply of sand and gravel, which can be found almost anywhere. True, the cement must be shipped in; but it goes at a very low rate, constitutes only a fraction of the total weight of the product, and is not subject to breakage or other loss.

In contrast to this, let us look at the conditions under which clay tile are manufactured. In the first place, a suitable supply of raw material must be found; and clay suitable for this purpose is not obtainable everywhere. Then, there must be specially designed buildings and an equipment of expensive machinery and the employment of skilled help. This means an outlay of anywhere from $30,000 up. It also means a large running expense for fuel to keep the kilns burning. All these facts mean that clay tile plants must of necessity be at a considerable distance apart and must work under the disadvantage of making long shipments by rail. The county, however, which does considerable tile work, could support one to three cement tile plants, and could thus secure tile without any rail shipments whatever.

Advantage of Price. In a large number of cases, due to some of the facts already mentioned, cement pipe can be sold at a lower figure than clay pipe. While the prices in most localities run along fairly uniform, any difference there may be is always in favor of the cement product.

Can Be Made to Suit Conditions. Another advantage is that a cement product of this character is very largely under control of the manufacturer. He can regulate its permeability to suit the conditions or the desire of the customer. While it is undoubtedly true that cement tile become more impervious with age, they will in most cases, under the ordinary process of manufacture, carry more water through their walls than clay tile, thus facilitating the drainage of the land.

Withstands Frost. Cement tile can be submitted to the

action of frost with more safety than clay tile. This does not mean that they should be left in the water indefinitely to thaw and freeze, but it does mean that they can be distributed over the ground in winter when it would not be safe to lay out clay tile.

Mr. F. A. B. Patterson of Fairmont, Minn., has made experiments which showed cement tile to be superior to clay in withstanding freezing. A 6-inch concrete tile and a 6-inch clay tile were placed in a V-shaped trough and water poured in so that the tile was more than half filled with water; the trough and tile were then placed outside and allowed to freeze solid, remaining so for two days. They were then thawed out and, upon examination, the concrete tile was found intact, whereas the clay tile was split from end to end in three places. Again, clay and concrete tile was placed in the ground and filled half full with a very thin mud, covered over to the depth of a foot of earth, and allowed to freeze; in the spring when it thawed out, the tile were examined and the same result as in the first experiment was shown.

Can Be Given Advantageous Shape. A sectional form can be given to concrete pipe which is more conducive to stability and efficiency than round clay pipes. While for purposes of even burning a nearly uniform thickness is desired for clay pipe, no such requirement is necessary for molded concrete pipe, which, when setting, retains its shape and grain. It is therefore possible to give concrete pipes better sectional forms. It is practicable and customary in Europe and in America to give concrete sewers a flat, broad and level base. Such a base has the advantage of allowing the pipe to rest firmly and securely upon a continuous flat earth foundation, as compared with the circular bed required for circular pipes, with the necessity of cutting out a depression in which the bells can rest. The difficulties of securing a perfect bearing for the barrel of circular pipes by tamping the earth backfilling into the space beneath the two sides of the pipe are not slight, and often have been the cause of a breakage of the pipe on account of

an insufficiently strong bearing due to hollows left by insufficient compression of the material. In fact, to get in this respect the same advantages as flat bottom cement pipe it is customary in some places to put a layer of concrete into the trench, upon which subsequently the vitrified pipe is laid, the concrete being then brought up to the spring of the pipe.

Easier to Make Joints. As cement pipes have a truer sectional shape than vitrified pipes, they can be given a slanting butt joint, as is customary in Europe, instead of the more clumsy bell and spigot joint common for vitrified pipe, which are made in imitation of cast-iron pipe used under high pressures.

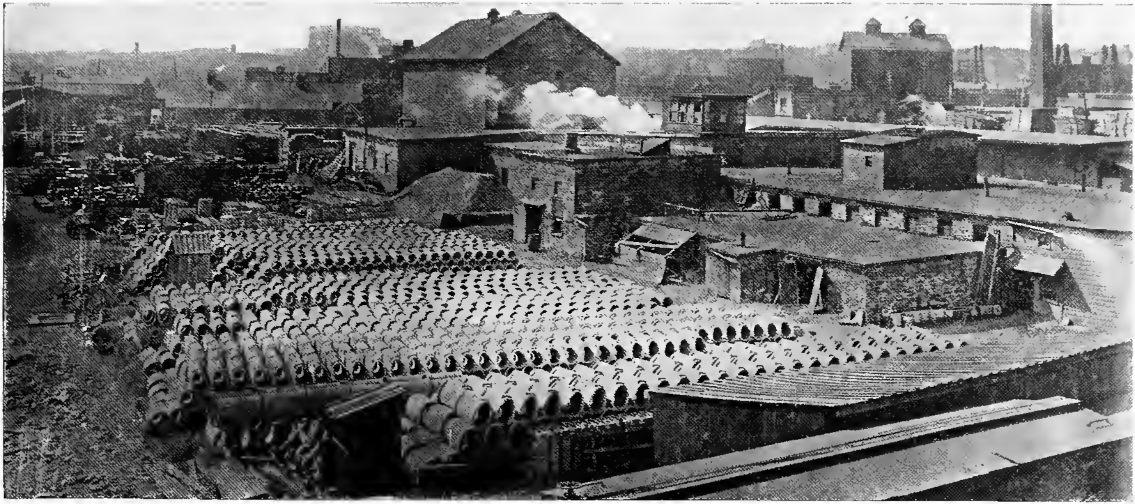
Breakage in Shipment. Sufficient data cannot be secured on shipments by rail of cement tile to establish any satisfactory percentage of breakage. In fact, as has been stated, one of the advantages of cement tile is the fact that it can be made close to the point where it is to be used, doing away to a large extent with the necessity of long shipments. Some manufacturers have shipped a number of car loads with not a single broken tile. At other times they have not been so fortunate and large numbers of tile have had to be replaced. In some instances, however, the fault has been so clearly with the railroad companies that they have made good the loss.

It is pretty well established that the breakage is not more than on clay tile and will probably run slightly less than 1 per cent on an average for a large number of shipments.

Manufacturers who ship tile in considerable amounts by rail prefer to cure it longer than the customary thirty days. One manufacturer says that he believes no tile should be sold under three months and he himself follows this rule almost invariably.

The following figures on shipments are given by Mr. H. J. Klemme of Belmond, Iowa: "Our experience in shipping tile has been to the extent of over 150 cars in the past nine months from distances of 10 miles up, the

longest distance being between 425 and 450 miles. In this car, which was loaded one-half of 4-inch and balance 5-inch cement tile, the breakage amounted to less than 20 tile. This was, however, a remarkable shipment, considering the distance. We have shipped several cars in succession without having a tile broken; then again we will sustain severe losses. We have entered out of all our losses six claims, varying from $6.86 to $49 to the car. The sizes shipped being from 4-inch, the smallest, to 30-inch, the largest. Our greatest number were the 5, 6, 7 and 8-inch tile."



PLANT FOR MANUFACTURE OF SEWER PIPE AT MILWAUKEE.

CHAPTER III.

Concrete Pipe Sewers.

Considerable skepticism has existed in the past, traces of which still remain, concerning the advisability of using concrete for the construction of sewer pipe. This fact is to be greatly regretted, the one encouraging feature in connection with it being that this feeling against concrete has not arisen by reason of any inherent defect in concrete itself, but rather in the careless, ignorant manner in which a large number of projects of this kind have been executed in times past. Even with a lack of accurate knowledge of the nature and methods of handling of concrete, large numbers of sewer projects have been successfully carried out in this material and are giving excellent satisfaction.

In order to give something of a resumé of conditions in regard to concrete sewers throughout the country, and to a certain extent in other countries, the writer has gathered together a considerable amount of material, some of it directly from city engineers themselves, concerning the usefulness of concrete as a material for sewers. This material is given in this chapter in the hope that it will show that concrete, even with the careless treatment which it has had in many cases, is a suitable material in every respect for sewer work. The writer believes also, as he has stated in the introductory chapter, that this is the greatest field for the immediate extension of the industry.

Two Cases in England. Mr. Arthur Collins, City Engineer of Norwich, England, made this statement: land made this statement under date of April 20, 1910: "I have some concrete sewers under my care in Norwich which were laid in 1891, varying in interior diameter

from 42 in. to 24 in., the total length of which amounts to several miles. They were brought into use for carrying sewage about 12 years since, and they show no signs whatsoever of deterioration. The main outfall discharges into a pair of concrete tanks forming screening chambers, and the concrete in these has not deteriorated. The sewage passing through these screens is pumped to the Sewage Farm, where for nearly 40 years it has been conveyed in an open concrete carrier, and in this there is no disintegration by chemical action."

Mr. Arthur C. James, Engineer and Surveyor to the Grays Urban District Council, stated recently before the Concrete Institute of England that he had charge of some sewage works, where practically the whole of the tanks and other works in connection with the sewage treatment were formed of concrete. The districts through which the sewage flowed were very flat, and when it arrived at the works it was not only very strong, but was highly concentrated, and rather in a septic condition, giving off a good deal of sulphuretted hydrogen. The tanks into which the sewage flowed were formed of Thames ballast and cement, 4 to 1 concrete, and they have now been in use between 15 and 16 years. The concrete was absolutely as good as the day it was put down. There was no sign of deterioration whatever. After having been pumped from these tanks, the sewage flowed into some septic tanks, also of concrete, in which there was no sign of deterioration at all.

Used for 40 Years in Germany. In a book which was recently issued by Professor Max Gary, the well-known chief of the Royal Testing Station for Building Materials, Gross-Lichterfelde, Berlin, who investigated the case of the destructive action of sewage and acids upon cement concrete pipes, an official record of the result of his investigation was given. From this report it appears that there are a number of towns in Germany where the officials reported the existence of concrete pipe sewers 40 years of age, and in summarizing the results of the reports officially obtained from the municipal authorities

in charge of those places, practically the whole of the records showed that the destructive action of sewage upon Portland cement concrete pipes had been very few in number. The Concrete Union of Germany, in discussing this very question, had laid great emphasis upon the necessity of a very careful ramming of the concrete work which came into contact with sewage, and he thought that the dangers which existed from the chemical actions which had been alluded to in this discussion would be very greatly minimized, if not altogether successfully resisted, by a very careful, complete, and thorough ramming of the concrete, and also if care were taken not to make the concrete too poor. As to filling the voids, one of the best, most successful and cheapest ways of filling the voids was with the cement itself, and it was a good deal better to have a rather richer mixture and prevent your deleterious fluids from penetrating into the fissures of the concrete at the outset than it was to have a dearer remedy afterwards.

A Paris Example. Recently a section of concrete sewer made sixteen years ago was placed on exhibition in Paris. For 12 years it had been used as a rising main, and for four years it had been broken into and remained exposed to the air. As far as could be ascertained, both internally and externally, the concrete was practically as sound as the day it was made, and when the concrete was broken away and the steel exposed it was perfectly bright; in fact it was clean; whereas when the steel had been put in it was all rusty.

Duluth, Minn., has had concrete pipe sewers for 20 years, their length aggregating about 14 miles. There have been no failures and the sections which have been taken up have been first class in every respect. The city engineer says they are incomparably better than sewers of other materials.

Portland, Ore., has put in over 26 miles of concrete pipe sewers within the past few years, but the installation is so recent that there is no available data as to its utility.

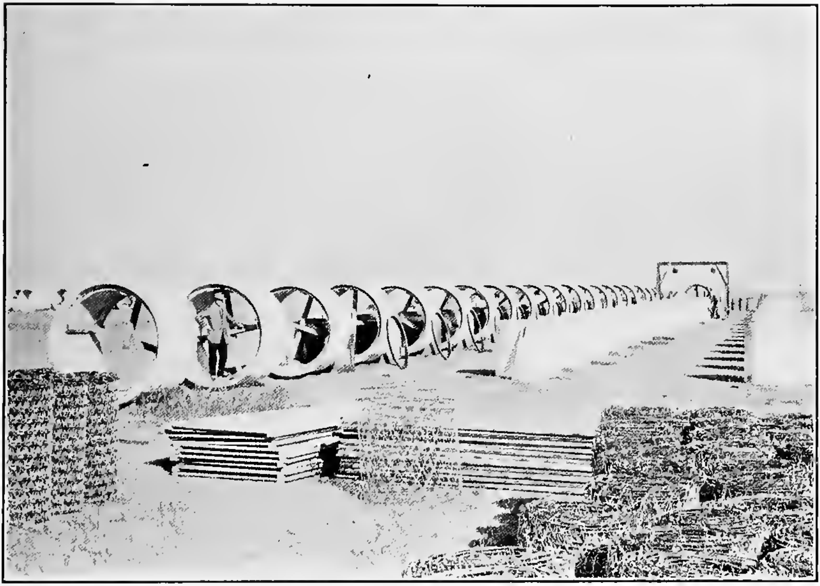
Charles J. Poetsch, City Engineer of **Milwaukee,** says: "The city of Milwaukee has used concrete sewer pipe for over 30 years with entire success and now has over 200 miles of such sewers in use. We find that they can be constructed cheaper and answer the purpose much better than brick sewers."

George S. Webster, City Engineer of **Philadelphia, Pa.,** says: "We have built a large number of sewers with concrete and the results has been entirely satisfactory."

A. W. D. Hall, City Engineer of **Jackson, Mich.,** says: "It has been my experience that concrete is more economical and stronger than sewer pipe made of either brick or clay. At the present time we have some three miles of concrete sewers, ranging from 15 inches to 66 inches in diameter. We not only consider this superior to any other class of sewers, but there is a saving in the expense not only in the laying, but in the maintaining afterwards."

Mr. F. W. Burt, of the Rhode Island Cement Drain Pipe Company, **Providence, R. I.,** wrote some time ago:

"Our city engineers have been somewhat prejudiced against cement and have not used it very much in what they call permanent sewers, but Rhode Island is a great manufacturing state and every town has several factories. To them we have sold quantities of cement pipe with satisfaction. The Atlantic Mills at Olneyville have over 3,000 feet of our 20x30-inch oval pipe that was put in about thirty-seven years ago. It was to carry off the expended dyes from the coloring vats. This dye is composed of acids, salts, potash, etc., and was discharged in the pipe at or near the scalding point. After it had been in use eighteen years, the city had occasion to remove two or three pieces in putting in water pipes and the cement was in almost as good condition as when put in. The inside did show a wearing out of the cement, leaving the pebbles a little more prominent, possibly about $\frac{1}{32}$ of an inch in depth.



LOCK JOINT PIPE FOR SEWERS.

"The top was stained with coloring, showing that it had run full at times. I think it is still in use. It speaks well for cement pipe. But it is well to bear in mind that this pipe was made of natural cement. Had it been made of Portland cement as it is made today it would have showed little if any wear. For the last ten years we have been putting a little Portland cement in all of our pipe and as the price of Portland has gone down, we have added more, until now we are using all Portland, and the result is a better pipe for the same money. Cement stands the fill much better than clay pipe; it can be laid near the top of the ground with safety."

Bangor, Me., reports having something less than two miles of cement pipe, 8 to 12 inches in diameter, which cost less than vitrified when laid; but vitrified pipe deal-

ers lowered the price, and have obtained the bulk of the trade since then, its manufacture in that city having been discontinued. The cement pipe laid was smoother than the vitrified, and had proved satisfactory; although some cement pipe, which was laid by the city before it had been properly seasoned and against the desire of the manufacturer, crushed but did not disintegrate.

In **Worcester, Mass.**, the cost of cement pipe is practically the same as that of vitrified clay.

In **Superior, Wis.**, more than a mile of 15 to 20-inch cement pipe was laid at a cost about the same as clay pipe, and has proved equally satisfactory.

In **Portland, Ore.**, about five miles of 9 to 12-inch cement pipe was laid about twenty years ago, the cost of which was not recorded, and has proved perfectly satisfactory.

In **Bellingham, Wash.**, cement pipe has been laid at a less cost than vitrified clay pipe, and has proved equally satisfactory.

In **Wabash, Ind.**, cement pipe costs less than vitrified when the diameter exceeds 15 inches, and is more satisfactory for such sizes.

In **Paris, Ill.**, the same is reported, but the limit of diameter is set at 24 inches.

City Engineer William A. Grover, of **Dover, N. H.**, reports that his trouble with cement pipe "has been chiefly that it was poorly made by careless, if not dishonest, manufacturers. I think it requires more skill to make good cement pipe than it does vitrified, and defects are not as readily detected. I am unable to give figures on the cost of manufacture, but cement pipe has always sold in this town about 30 per cent below the other. I have had occasion to dig up several cement pipe drains which had been down less than fifteen years, and have found them disintegrated; but this I do not think is typical of cement in general, but only of this cement pipe in particular."

Watertown, N. Y., has two miles of concrete pipe sewers which is reported as giving the best of satisfaction.

G. H. Randall, City Engineer of **Oshkosh, Wis.**, says he knows from actual experience that properly made concrete sewers are best for a combined system of sewerage. He says sewers laid during the 80's are in good condition today. Oshkosh sewers have been held up as an example of the futilities of concrete, but regarding them Mr. Randall writes:

"I don't believe a single foot of cement pipe failed in this town from the action of acids. Almost all of the trouble we had here was caused by insufficient covering of the pipe; they froze and were broken by expansion of ice or disintegrated by freezing and thawing.

"Between 1892-1896 cement pipe were poorly made. The company that made the pipe used Portland cement and natural cement mixed with sand and gravel. The sand and gravel were of good material.

"In the first place natural cement should not be used with Portland; in the second place, there was a very small portion of Portland cement used.

"Cement pipe were first used here in 1884. My father was engineer and I was his assistant. Between 1884 and 1892 the pipe were much better and we have all of these sewers in use today except a few streets where we took them up to enlarge them.

"The first cement sewers are in the business and thickly settled portions of the city, and although natural cement was used in their manufacture, they are in good condition today. We are tapping them every day, and the workmen say the first sewers are in fine condition. Now, this is the district where sewer acids would destroy the pipe, if anywhere.

"I don't know of any place in Oshkosh where cement pipe have failed that vitrified pipe would not have failed. In the first place, I think 1,000 feet would cover all the pipe of cement that had to be replaced because it had broken down, and that was broken by the steam roller because of the telford foundation resting on the top of the pipe, or from freezing.

"Our sewer system is the combined system, and sewer-

age proper (that is, the solids) is well flushed by the storm water. Our cement pipe are not what they ought to be, but considering the conditions I think it wonderful we have had so little trouble. We have had to replace over 1,200 feet of vitrified pipe that went to pieces where there was no excuse for it, except poor pipe."

Janesville, Wis., has two miles of 27 and 48-inch storm sewer of concrete pipe, all reported in apparently good condition. City Engineer C. V. Kerch says concrete is cheaper for this purpose than any other material and has no disadvantages.

Pawtucket, R. I., has been building concrete sewers since 1904 and Geo. A. Carpenter, City Engineer, reports that they have proven very satisfactory.

Springfield, Mass., had some unsatisfactory experience a number of years ago, due to improper methods of manufacture of concrete sewers, but is again making them, and they are reported very satisfactory by Chas. M Slocum, City Engineer, who says they are cheaper than sewers of other materials.

Kinds of Concrete Sewer Pipe. Concrete pipe for sewers can be classified under three heads: Plain sections without joints, bell-end sections, and sections with tongue-and-groove joints.

The plain sections are rarely used for sewer work, inasmuch as a collar has to be cast around the joints, which is more difficult and more expensive than the other forms of joints. This can sometimes be used to advantage, however, on short stretches of sewer, where it is impracticable to put in an outfit for the manufacture of other styles of pipe. The sections for this form of sewer can be manufactured on a power pipe machine or with any one of the various styles of hand molds.

The bell-end pipe is very satisfactory in some respects, one of them being that it resembles in shape the ordinary vitrified clay pipe or iron pipe and laborers will therefore be somewhat more familiar with methods of handling it. The joints for this class of pipe are usually closed by pouring in a cement grout. One objection to this

form of pipe is that it requires more cement than some other styles and the jackets usually have to be left on until after the concrete has set in order to protect the bell-end. In the larger sizes which require reinforcing, it is not always easy to frame and place the reinforcing in such a manner that the bell-end will be properly taken care of. It is a significant fact, however, that a number of machines are just now coming on the market for the manufacture of sewer pipe of this style by power. Some of these make the claim that the jackets can be removed immediately after the section of pipe is taken from the machine. It would seem that, especially for small sizes, machines of this kind would find a ready sale in the sewer pipe field.

The tongue-and-groove sections are usually made with a plain tongue and groove for the smaller sizes, and with special interlocking joints in the larger sizes, made by various patented systems of which there are three or four now in the field. These are described in Chapter XII. A joint of this kind is not only economical in the use of materials, but also furnishes a smooth outer surface so that a special preparation of the bed is not necessary.

Cost of Sewer Pipe at Waukegan, Ill. In 1908, Waukegan, Ill., put in concrete pipe sewers at the following prices:

2224	feet	of	60-inch	at	$10.85	per foot.
2405	feet	of	42-inch	at	6.60	per foot.
3425	feet	of	36-inch	at	5.05	per foot.
1200	feet	of	30-inch	at	4.80	per foot.
9600	feet	of	24-inch	at	3.80	per foot.

This price included excavation and laying, and a two-year guarantee. Sand and stone were $1.75 a yard, labor $1.75 and $2.00 per day.

Cost of Manufacturing 42-inch Pipe Sewer at Mishawaka, Ind. The city of Mishawaka, Ind., added nearly six miles of concrete sewer to its system during the summer of 1908, this amount including 17,000 feet 42 inches in diameter. The sewer is of reinforced concrete pipe, made in 3-foot interlocking sections.

The contractor, who had personal charge of this job, found considerable trouble in getting satisfactory labor to manufacture the sections, and with six men at $1.60 per day and with himself giving a large amount of his time to looking after them, he was scarcely able to turn out the 60 feet which it was planned must constitute a day's work. He thereupon secured five Hungarians and told them that he would pay them $9 per day collectively, or $1.80 each, to turn out 60 feet, and that they could quit when that amount of work had been done. The plan worked admirably. The contractors got the full daily quota of sections without trouble or waste of their own time, and the Hungarians stuck to their job, as they were making 20 cents a day more than the other men, in addition to getting away an hour or more before quitting time each day.

With the men making 60 feet at $9.00, the contractor could figure on an unvarying unit cost of 15 cents per foot. The excavation from the trench furnishes a very good grade of mixed sand and gravel, which is used in making the sections, being mixed with cement in the proportion of 1 to 5. As the haul was short, one man and team at $4.00 per day hauled enough sand and gravel in one day to keep the men busy two days. This $4.00 must therefore be equalized over 120 feet of pipe, making a cost on this item of 3⅓ cents per foot. It took 55 sacks of cement or 13¾ barrels, for each day's work. At $1.35 per barrel, delivered on the job, this makes a daily cost for cement of $18.56, or practically 31 cents per foot. Adding these items we get the following results:

Men on forms	$0.15
Hauling sand and gravel	.03⅓
Cement	.31
Total cost per foot	$0.49⅓

Of course, this does not include reinforcing, which is furnished by the company controlling the patents, nor

the royalty paid to that company for the use of its forms.

Output of 12-inch Sewer Pipe. One of the principal sizes of concrete sewer pipe used in Milwaukee is an oval 12-inch in greatest diameter, and 18 inches long. These are hand made in heavy cast iron molds. Two men, with concrete delivered to them by the mixing crew, make thirty of these sections a day as an average.

CHAPTER IV.

PIPE FOR PRESSURE SERVICE.

Concrete is especially well adapted for the construction of pipe lines to carry water under pressure. The life of wood pipe is short, especially if the flow of water through it is intermittent. Steel pipe is expensive, and is likely to encounter soil conditions which will cause it to disintegrate. Pressure pipe, also, is likely to be used in barren and sparsely settled territory, lacking sufficient transportation facilities for the conveyance of made-up sections, such, for instance, as the reclamation projects of the West.

One such, on the Umatilla Project in Oregon, was described in detail by Herbert D. Newell in Engineering Record for February 16, 1911, from which account we take extensive extracts by permission.

The pipe line first under consideration was one of 46-in. inside diameter, which would have a length of 4,700 ft., and would be subjected to a maximum head of about 55 ft. Experiments on two sections were made at Portland, Ore., in the summer and fall of 1906. They seemed to warrant the following conclusions, which actual construction and operation have since shown to be correct:

(a) That the steel used for circumferential reinforcement may be subjected to a stress of about 12,500 lbs. per sq. in. without causing appreciable leakage in the concrete.

(b) That the cement joint used could be depended upon to resist a pressure of 30 lbs. per sq. in.

(c) That a 3-in. shell was amply sufficient to resist internal pressure and ordinary handling.

(d) That a coat of plaster ½-in. thick well applied would successfully resist percolation under pressures corresponding to about 100 ft. head.

The main forms consist of an inner core of ¼-in. steel plate 8 ft. in length with a key piece. The inner core is hinged to permit its being collapsed when the key piece is removed. It was first planned to place a ½-in. plaster coat on the inside of the pipe, so the outside diameter of the core was made 47 ins. in order that the finished pipe might have a diameter of 46 ins. The outer forms are segmental, three segments making a circumference, the segments being 2 ft. high. They are made of ⅛-in. steel plate, stiffened by 2x3x$\frac{3}{16}$-in. angles. The inside diameter of the outer forms is 52 ins.

The first cost of the forms, including 50 cast-iron base rings, was nearly $1,900. The workmanship on the forms as originally delivered was imperfect. The inner core was not cylindrical and the outer segments were not true. As a result pipe made the first season had a shell of varying thickness, and there were often pronounced offsets, sometimes nearly as much as an inch, where one segment joined another. During the winter of 1907-8 the forms were sent to Portland to be trued up and put in good condition. The diameter of the inner core was reduced from 47 ins. to 46 ins., and necessary changes were made to the base rings. The cost of these changes was about $1,125, making the total cost of the forms slightly over $3,000.

Collars—The collars were of concrete, the same mixture being used as for the pipe. They were 3 ins. wide and 3 ins. thick. The first season they were reinforced with No. 13 expanded metal. This did not prove entirely satisfactory as there developed a tendency for the concrete to separate from the reinforcement. In other words, unless the collar remained in the form until thoroughly set, quite a percentage would split along the face of the reinforcing belt. Again, in making the joint in the field the expanded metal proved somewhat brittle.

The second season, in 1908, the collars were reinforced

with two pieces of $\frac{5}{16}$-in. mild steel wire hooked at the ends. These were cheaper than the expanded metal and were free from the tendency of splitting along the plane of reinforcement. However, collars reinforced with either expanded metal or with $\frac{5}{16}$-in. wire proved weak unless carefully handled.

The third season, in 1909, all collars used where the head acting on the pipe was over 50 ft. were reinforced with No. 3 rib stud supplied by the Trussed Concrete Steel Co. Although this reinforcement contained an unnecessary amount of metal, it was the only standard article at hand and proved very satisfactory.

In some cases collars have been cast in the field after the pipe has been laid. In such cases either steel wire or the rib stud has been used for reinforcement. The form used is flexible and can be wrapped around the pipe like a belt.

With only twelve forms available it quickly developed that in order to give the concrete sufficient time in which to set only six pipes could be regularly made each day. The pipe were cast with a nominal thickness of shell of 2½ ins. with the expectation that ½-in. of mortar would be added on the inside. It was soon found, however, that a mortar coating on the inside of the pipe was very expensive, and the work was not satisfactory on account of the difficulty in getting a good bond. It was decided then to discontinue plastering, and fully 85% of the pipe in the M line has a shell nominally 2½ ins. thick. However, on account of the inaccuracy of the forms, the shell of the pipe was not of uniform thickness, there being frequent offsets at the junction of the different segments of the outside form, so in many cases the minimum thickness of shell was not more than 2 ins., and possibly a trifle less.

While the work of making 46-in. pipe was in progress it was decided to build about 3,000 lin. ft. of 30-in. concrete pipe. For this purpose wooden forms were built on the project. The pipe was cast in 4-ft. lengths with a bevel and tongue joint and a thickness of shell of 3 ins.

The inside form was made in two main segments, the cylinder being completed by means of a key piece. The outside form was in three parts, which were assembled by bolts. Both inner and outer forms were lined with No. 26 sheet steel.

Considering one sack of cement as 0.9 cu. ft., the proportions by volume were approximately 1 part cement, 2.3 parts sand and 3 parts gravel. The sand was a dark blue sand, obtained locally. It was very clean, rather uniform in size, and of medium coarseness. The gravel all passed a screen of 1-in. mesh, and was rejected by a screen of ¼-in. mesh.

The reinforcement used consisted of $\frac{5}{16}$-in. mild steel wire wound on a drum into a helical coil. The spacing was such as to permit a maximum stress of about 12,000 lbs. per sq. in. The coils used the season of 1907 for 47-in. pipe were made by the Portland Wire and Iron Works, who received 4½ cts. a lb. for the manufactured coil, and furnished all labor, materials and appliances. A second contract was entered into with the same company for reinforcement for 30-in. pipe.

The trench was excavated in the fall of 1907. Laying pipe for the M pipe line* began in November, 1907, and the line was completed February 1, 1908. Its diameter was 47 ins., length 4,680 ft., and maximum head 55 ft. The line was tested in the spring of 1908. There were a number of minor leaks, and one sufficiently pronounced to warrant an examination. It was found that leakage resulted from a defective collar which was placed when the temperature was about zero. This leakage was easily repaired and the line filled. It has been in use three seasons and has given complete satisfaction, nothing having been spent for repairs. It is found that there is some leakage when water is admitted in the spring, but as the weather gets warmer the leakage disappears. Again, a little leakage may be perceptible in the morning, and in the warmer part of the day it will entirely cease.

The experience with the pipe lines laid during the

* The different lines are tabulated in Table 1, Page 36.

winter of 1907 was sufficiently gratifying to warrant the making of concrete pipe during the season of 1908; 7,056 lin. ft. of 46-in. concrete pipe were made, and 9,216 lin. ft. of 30-in. pipe. The cost of 46-in. pipe in the yard, exclusive of reinforcement, was about $1.56 per lin. ft. for labor and material, and $2.24 per lin. ft. reinforcement included. The cost of 30-in. pipe without reinforcement was about 87 cts. per lin. ft., with reinforcement about $1.25 per lin. ft. The foregoing figures do not include the general expense charge.

The mixture of concrete was the same as the previous year. The reinforcement was made by force account, and cost $0.04 per lb. for the completed coil. The 46-in pipe was used in laying the O1 and R2 pipe lines, and the 30-in. pipe in laying the O2, R3 and B lines.

The experience of the two previous seasons caused the engineers to consider favorably the idea of using concrete pipe for the R1 pipe line. This would have an inside diameter of 46 ins., a length of over 9,800 ft., and would act under a maximum head of 110 ft. There was no doubt whatever that the pipe would be satisfactory for heads up to 75 ft. In order to determine whether or not the pipe would be satsfactory under a higher head, experiments were made in the spring of 1909.

Four test sections of pipe were made. These sections had an interior diameter of 46 ins., a thickness of shell of 3 ins., and a length of 4 ft. Considering one sack of cement equivalent to 0.9 cu. ft. the proportions by volume of the materials forming the concrete were 1 part cement, 1.44 parts sand and 2 parts gravel. The sand and gravel were similar to that used the two preceding seasons. All the test sections were reinforced with a double coil of $\frac{5}{16}$-in. wire with 1¼-in. spacing. An effort was made to obtain wire of $\frac{13}{32}$-in. diameter, in which case a single coil would have sufficed. The Portland market was unable to furnish wire of the desired size, so it was necessary to make use of $\frac{5}{16}$-in. wire which was in stock, and in order to obtain sufficient strength it was necessary to use a double coil. As an important feature of the test was

to determine the strength of the joint, the four sections were joined together in pairs, making two sections 8 ft. long, the joint being made as nearly as possible under conditions which would be approximated in the field.

The joint consisted of two parts, an outside collar which was placed first and cemented to the pipe with mortar composed of 1 part cement and 2 parts sand. After the cement joint had set, the inside joint was completed, using a mortar composed of 1 part cement and 1½ parts sand. The collars were reinforced with No. 3 rib stud made by the Trussed Concrete Steel Co. One collar was made of three segments cast in molds, seasoned, and afterwards cemented to the pipe. The other collar was cast directly on the pipe. The tests showed that:

(a) 46-in. concrete pipe with a 3-in. shell would stand pressures of 50 lbs. per sq. in. without excessive percolation.

(b) That both types of collar were satisfactory.

The tests were deemed sufficiently satisfactory to warrant building the entire line of concrete. During the season of 1909, 9,216 lin. ft. of 46-in. reinforced-concrete pipe were made, having an average cost per lineal foot of $1.72, exclusive of reinforcement, and $2.97 including reinforcement. During that season 6,360 lin. ft. of 30-in. reinforced-concrete pipe were made, having an average cost per lineal foot of $1.02, exclusive of reinforcement, and $1.26 reinforcement included. The reinforcement was made by force account at a cost of $0.028 per lb. for the completed coil. The foregoing figures do not include the general expense charge. The 46-in. pipe were used for the R1 line and the 30-in. pipe for the R4 and D1 lines.

The R1 pipe had a diameter of 46 ins., a length of 9,831 ft., and a maximum head of 110 ft. The work of laying began in November, 1909, and the line was finished in January, 1910. The pipe was tested on February 28, 1910, it being filled in two hours and forty minutes. There were no mishaps and no leakage was apparent in that portion of the line subjected to maximum pressure.

One or two slight leaks developed where the head was about 60 ft. These were repaired at a cost less than $10 The line was in continuous use during the season of 1910 and gave perfect satisfaction.

During the season of 1910 about 4,000 lin. ft. of 30-in. pipe were made for the T1 and T2 pipe lines listed in Table I.

It has been the general practice to give all pipe subjected to a pressure of more than 12 to 15 lbs. one or more coats of cement grout. This has proved helpful in decreasing percolation through the pipe, particularly where the pipe is made of a mixture rather lean in cement. About one-half a bucket of cement is stirred into two-thirds of a bucket of water. This will give a full bucket of a mixture having about the consistency of

TABLE 1.

Tabulation of Reinforced-Concrete Pipe Laid.
Umatilla Project, Ore., U. S. Reclamation Service.

	Inside Dia. Inches	Max. head, ft.	Length ft.	Cost per lin. ft. in place ready for use: Excluding General Expense	Including General Expense
R1	46	110	9,831	$4.43	$5.17
R2	46	15	1,284	3.26	4.04
*M	46 & 47	55	4,680	5.43	6.14
O1	46	36	5,312	3.86	4.51
D1	30	45	5,330	2.25	2.69
D2	30	22	1,724	2.37	2.67
†D3	30	35	1,395	3.09	3.51
O2	30	26	3,556	2.45	2.93
R3	30	25	3,645	2.04	2.43
‡B	30	55	932	3.31	4.24
R4	30	18	1,622	1.96	2.30
K	30	9	524	2.28	2.57
§T1	30	8	1,398	2.44	2.66
§T2	30	18	2,495	2.62	2.83

*High cost due to its being the first line laid, and to the fact that it is charged with preliminary and experimental work.

†High cost due to rock in trench and to railroad crossing.

‡High cost due to rock in trench and to presence of water.

§High cost due to mixing by hand with a small crew and to a long haul over sandy roads.

cream. Tests have been made on various coatings which were painted on the inside of the pipe. The experience has been that the cement grout is much cheaper and at least as effective.

To the cost per lineal foot given in the accompanying tables there should ultimately be added about $0.08 per lin. ft. for depreciation on Forms for the 46-in. pipe, and probably $0.10 or $0.12 per lin. ft. for all other depreciation.

TABLE 2.

R1 Pipe—Detailed Statement of Cost.

46-in. Reinforced Concrete, 9,831 ft. long—Maximum head, 110 ft.

Item.	Total cost	Cost Lineal ft.
Engineering	$ 471.17	$ 0.048
Labor—		
Cleaning sage brush from line	59.17	.006
Excavating trench	2,336.13	.238
Backfilling and protecting line with brush	1,884.92	.192
Hauling pipe from pipe yard	2,901.75	.296
Laying pipe and making joints	3,817.59	.388
Tests on experimental sections	341.21	.034
Painting pipe with cement grout	427.00	.043
Priming pipe	22.77	.002
Miscellaneous and miscellaneous hauling	877.47	.089
Cement pipe, charge from mfg. plant	28,554.14	2.905
Materials, cement	680.57	.069
Miscellaneous materials and supplies	780.04	.080
Castings, valves and manholes	369.45	.037
Total	$43,523.28	$ 4.427
General Expense	7,282.26	.741
Grand Total	$50,805.54	$ 5.168

NOTE: Pipe line is located about three miles from yard where pipe were made. Roads were sandy. Sand for mortar was sacked and hauled about three miles. Weather too cold for best work. Crew laid off twice —total, 11 days. Laying pipes in trench began Nov. 2, 1909 and was finished Dec. 31, 1909. Placing collars and making joints began Nov. 14, 1909 and was finished Jan. 11, 1910. Mortar mixed with hot water. Weight of salt added to water about 10% of weight of water used. Ends of pipe thawed before making joints. Minimum temperature 2° below zero, temperature while work was in progress 12° above zero or warmer, but seldom much above freezing point.

Average force, 35 men and 7 teams. Wages: Foreman, $150 per month; carpenter and blacksmith, $3.40; laborers $2.20 to $3 per 8-hr. day; 2-horse team and driver, $4.25 per day.

TABLE 3.

R3 Pipe—Detailed Statement of Cost.

30-in. Reinforced Concrete, 3,645 ft. long. Maximum head, 25 ft.

Item.	Total cost	Cost Lineal ft.
Engineering ....$	57.64	$ 0.016
Labor—		
Clearing sagebrush from line..............	69.51	.019
Excavating trench	712.74	.196
Backfilling and protecting line with brush..	212.77	.058
Hauling pipe from pipe yard..............	670.56	.184
Laying pipe and making joints............	755.86	.208
Miscellaneous and miscellaneous hauling...	327.39	.090
Cement pipe, charge from mfg. plant...........	4,465.52	1.225
Materials, cement	54.82	.015
Miscellaneous materials and supplies..........	42.63	.011
Castings valves, manholes.....................	66.50	.018
Total ....$	7,435.94	$ 2.040
General Expenses	1,428.45	.392
Grand Total ....$	8,864.39	$ 2.432

NOTE: Line is located about 2½ miles from yard where pipe were made. Roads were sandy. Water was hauled about 2½ miles. Mortar was mixed with hot water and weight of salt added to water was about 10% of weight of water used. Ends of pipe were heated before making joints. The line was laid in January and February, 1909.

Wages: Foreman, $150 per month; carpenters and blacksmiths $3.40; laborers, $2.20 to $2.80 per 8-hr. day; 2-horse team and driver, $4.25 per day.

Reinforced Pipe at Pueblo, Colo. More than 18,000 linear feet of hub and spigot concrete pipe, in 30 and 38-inch sizes, was made in connection with the development of a water system at Pueblo, Colo., as described in The Engineering Record for April 4, 1908. This pipe was all in 2-foot lengths, the shell of the 38-inch size being 3¼ inches and that of the 30-inch size 2½ inches thick. The concrete was made in the proportions of 1 part Iola Portland cement to 4½ or 5 parts of gravel obtained from the river, depending on the percentage of voids in the gravel. The latter was of excellent character for the purpose, varying from sand to stone that would pass a

¾-inch screen. The concrete was all mixed by hand, and was thoroughly hand-tamped in the molds in which the pipes were cast.

The concrete pipes were made at a cost below that of any other satisfactory material that could be delivered at the work. The two parts of the outer shield are fastened together with lock levers of very simple design, these levers and locks being attached to the reinforcing angles. The shield is placed on the base ring, the latter being made so it forms the hub of the pipe.

The first pipes were made at the river end of the 30-inch waste line, but soon after the work was started cold weather set in, so a 50x100-foot frame warehouse, ceiled with corrugated sheet iron, was erected adjacent to the main gathering gallery, and the remainder of the pipe made in this warehouse during the winter. Sheet-iron stoves were installed to maintain the temperature in the building, and other precautions were observed to protect the new pipe from freezing.

The cost of the first pipe made was somewhat higher than the average, owing to the inexperience of the molders, and to other causes, but was at no time up to the cost of other material that could be used. The average cost of the plain pipe when made in the warehouse was very close to $1 a foot for the 38-inch size and 75 cents a foot for the 30-inch size. The cost of the reinforced pipe was increased over that of the plain practically by the cost of the reinforcing material, as the method by which the concrete was placed in 4-inch layers in making the plain pipe permitted the reinforcement to be inserted without added expense. The costs given include every expense, even to a proportionate charge for construction camp expenses, the watchman's salary, coal for heating the warehouse, and the labor required in rolling the pipes out of the warehouse. Laborers were paid $2 and a foreman $3 a day, the one foreman running the whole gang. The cement cost $2 a barrel at the railroad station, two miles from the work. The gravel was hauled about one-half mile with teams at 40 cents an hour,

each team hauling six or seven 1 cubic yard loads in 10 hours.

Some Oregon Figures. Mr. Albert E. Wright gives the following account* of the method and cost of molding and laying 6 to 12-inch cement pipe for work at Irrigon, Oregon: The pipe was 6 to 12 inches inside, made of Portland cement and clean, sharp sand of all sizes up to very coarse. The mortar was mixed rather dry, but very thoroughly, using 14.1 cubic feet of sand to 1 barrel of cement, or very closely a 1 to 4 mixture. From six to seven buckets of water were used to each barrel of cement, except for 6-inch pipe, for which the mortar had to be made somewhat stiffer in order to remove the inner form, which was not made collapsible as in the larger sizes.

The forms were sheet iron cylinders with a longitudinal lap joint that could be expanded after molding the pipe, and removed without injuring the soft mortar. The inner form was self-centering, so that there was little variation in the thickness of the pipe.

Four men were required in making cement pipe by hand; one mixed the mortar, and wheeled it to the place of work; another threw it into the form a little at a time with a hand scoop; a third rammed it with a tamping iron, and a fourth kept the new pipe sprinkled, and applied a coat of neat cement slurry to the inside when it was sufficiently hard. In molding, the form of the bell at the bottom was secured by an iron ring that was first dropped into the form, and the reverse or convex form at the top was made with a second ring. While still in its form the pipe was rolled or lifted into its place in the drying yard, and the form was then carefully removed. A very slight blow in removing the form would destroy the pipe, and a considerable number, especially of the larger sizes, collapsed in this way, and had to be remolded. To avoid handling, the pipe was stacked on end a few feet from the place of mixing, the form being moved as the yard filled with pipe. One crew of four

* "Concrete Construction: Methods and Cost," by Gillette and Hill.

men could make about 250 joints or 500 lineal feet of pipe a day.

As soon as hard enough, the pipe was turned end for end, and was then kept wet for several weeks before being laid. The coating of neat cement on the inside was applied with a short whitewash brush, and was a small item in the cost.

In laying, the trench was carefully finished to grade in order to have the joints close nicely, and the ends were well wet with a brush. The mason then spread mortar, mixed 1 to 2, on the end of the pipe, and laid a bed of mortar at the bottom of the joint. He then jammed the section in place, and swabbed out the inside of the joint with a stiff brush, to insure a smooth passage for the water. A band or ring of mortar was spread around the outside of the joint as an additional reinforcement. One barrel of cement would joint about 300 sections of pipe. The materials cost as follows: Portland cement, per barrel, $4.45; labor, per day, $2; foreman, per day, $2.50 to $3; hauling, per load mile (1 cubic yard), 20 cents; sand, free at pit; water, free.

By carefully working out the voids, and the amount of cement required, the following cement costs per foot were arrived at, cement being $4.45 per barrel:

Diameter, inches.	Thickness, inches.	Cost, per foot.
6	1¼	$0.0571
8	1¼	0.0730
10	1⅜	0.0998
12	1½	0.1278

The sand cost was based on 15 cents per cubic yard for loading, and a haul of two miles of 1 cubic yard to the load, making five trips per day, at $4 for man and team. It bears a constant ratio to cement cost, being 11.2 per cent of the cement cost. The labor cost of making was based on the foreman's estimate that a foreman, tamper, mortar mixer, and water man should finish 250 joints a

day of 6 or 8-inch pipe. For the 10 and 12-inch pipe, the labor was assumed to be greater in proportion to the material. The foreman was taken at $3, one man at $2.50 and two at $2. The cement for painting the inside was neglected. Hauling the pipe to place was taken at twice the cost of hauling the sand per mile, and a haul of four miles was assumed. The cost of laying was based on a foreman's estimate of 2 cents per foot for trench, and that one man to lay, one man to plaster the joints, one helper and one man to backfill would lay 600 per day of 6 or 8-inch pipe. The larger sizes were assumed to cost more in proportion to their material.

These various costs gave the following results for small size pipe:

	Cost per foot for			
	6-inch pipe	8-inch pipe	10-inch pipe	12-inch pipe
Cement	$0.057	$0.073	$0.099	$0.128
Sand	0.006	0.008	0.011	0.014
Labor	0.019	0.019	0.026	0.034
Hauling	0.024	0.032	0.044	0.056
Laying	0.024	0.024	0.032	0.042
Trench	0.020	0.020	0.020	0.020
Totals	$0.150	$0.176	$0.232	$0.294

Concrete Pipe Siphons. Siphons of concrete pipe on the new domestic service line of the Temescal Water Company extending from the source of supply at Coldwater Canyon to the city of Corona, Cal., a distance of about 7½ miles, were described in Engineering Record for November 4, 1911. About 27,000 feet of the line, at the hydraulic gradient, is constructed of plain concrete pipe 22 in. in diameter; there are, however, 15 depressions in the country crossed by the line where inverted siphons are used. Thirteen of the siphons are of reinforced concrete pipe, 20 inches in diameter, which is subjected to a maximum head of about 88 feet.

The difficulty of working in small pipes was the reason

that reinforced concrete was not used on the two siphons where steel was adopted. On larger size pipe, however, the company which made and laid the pipe line to Corona claims to be prepared to enter into contracts for heads up to 150 feet. Owing to the wide range of aggregate materials in the western country it is difficult to make a general statement regarding the limiting head for which reinforced concrete pipe may be used; each piece of work must be considered separately. It has been the company's experience that with ordinary materials good results may be obtained with a 1:2:4 mixture for heads up to 40 feet, even using walls as thin as 2¼-inch. A 1:2:3 mixture, with carefully proportioned aggregates, is said to be suitable for heads as high as 150 feet, although with such a pressure waterproofing is necessary. Under heads of 50 feet or more the pipe usually "sweats" during the first week or so after water is put into it; the sweating, however, is said to cease in a short time.

CHAPTER V.

Concrete Pipe for Culverts.

Concrete is being used by railroads, highway commissioners, and the like, for culverts, for which purpose it is remarkably well adapted.

The Chicago, Burlington and Quincy Railroad Company is operating an interesting concrete pipe plant at Montgomery, Ill., about 40 miles from Chicago. These pipes are used in replacing culverts, where the flow is comparatively small, in new construction and reconstruction work. In some cases trestles of considerable length have been replaced by embankment containing concrete pipes. Pipes from Montgomery are shipped to all parts of the system.

The pipes are made in three sizes, all reinforced, and are elliptical in cross section. This form is adopted because it has greater strength than the circular form of the same capacity when it is placed in the fill with its short diameter horizontal. The largest size is 52 inches on its long diameter and 48 inches on the short one. The second size is 40 inch by 36 inch and the smallest 28 inch by 24 inch. The difference between the long and short diameters is the same for all sizes, namely 4 inches. The length is uniformly 8 feet over all, but a 4-inch bell makes the pipe measure up to 7 feet 8 inches when joined in position. The thickness is 4 inches throughout in all sizes. The bell is given an inside diameter such that ½-inch clearance is allowed all around the joint with another pipe to provide for slight unequal settlements without putting a strain on the pipe ends.

The largest size pipe is reinforced with a shell network of 1/3-inch square corrugated bars, made up of hoops

spaced 3 inches and longitudinal bars spaced 9 inches, wired at all intersections. The longitudinal bars are bent so as to run continuously into the bell, and two hoops are passed around them inside the bell. This shell of reinforcement is placed eccentrically inside the body of the pipe, the hoops being ¾ inch from the inner face of the concrete at the top and bottom and ¾ inch from the outer face at sides. This throws the reinforcement where the tension would naturally come when a crushing load is put on the top. To accommodate this arrangement of the hoops, the longitudinal bars are placed outside the hoops at the top and bottom and inside the hoops at the side, thus bringing them nearer the center all the way around.

The two smaller sizes of pipe are reinforced with Northwestern expanded metal, a single sheet being rolled into a cylinder for the body of the pipe. This metal is rolled against its natural bend, that is, in the direction of the longest cut, since it has been found to be strongest when so placed. The expanded metal cylinder is placed in these pipes in a similar eccentric position to that of the corrugated bar hoops already described. In this case the bell is reinforced by 18-inch lengths of the ⅓-inch square corrugated bar, wired to the expanded metal and bent into shape. Two hoops made of the bar are used around the bell.

A test made on a pipe of the largest size at the University of Illinois showed a load of 48,000 pounds before any evidence of failure appeared, and was not completely broken down until the load had exceeded 200,000 pounds. The largest pipes weigh about 3 tons each, the second ones 2¼ tons and the smallest 2 tons.

The plant for manufacturing the concrete pipes includes a mixing yard, molding house, curing house, platforms for assembling and removing molds, boiler house, reinforcement shop, storage yards and office. It is equipped to run summer and winter. The molds and fresh pipes are handled entirely on a system of industrial tracks and cars, which serves the assembling platforms, molding and curing houses. A siding from the C. B. and Q. tracks

delivers material to the plant and receives the finished pipe.

The manufacture of a pipe starts with the assembling of the mold on the platform at the east end of the yards. The molds are of wood, lined with sheet iron, and are made up in four principal sections, two semi-cylindrical sections making up the core of the body of the pipe, and two half sections making up the entire outer shell. The two sections of the core are similar to ordinary metal-covered sewer centers. A longitudinal wedge-shaped stick of wood is placed between these sections on each side, and struts inserted to hold them in position, and then the two sections are locked together at the ends by metal latch plates.

The outer shell sections are made up of lagging, bound together by hexagonal frames. The sections are fastened together by binding bolts on each of these outside frames, these bolts lifting out of their sockets as soon as the nut is loosened. To insure a solid form of the larger pipes, adjustable steel bands are also put around the body between the frames. The outer mold is shaped at one end to form the bell, and lined to a neat finish. The core of the bell end is formed by two small semicircular pieces and wedges, with edges shaped. This is clamped to the core after the body of the pipe has been cast.

An industrial track passes through the center of the assembling platform so that the top of the car is flush with the platform. A derrick commands this platform for handling heavy mold sections and finished pipes. The core is put together on a car here in an upright position, the bottom of the core being held in place by four 4-inch steel lugs on the car floor. Putty is put on the wedges to make a tight and easy slipping joint. The reinforcing shell, which has been previously woven and shaped in the reinforcement shop, is then slipped over the core by the derrick. It is placed in position by inserting a ¾-inch piece of gas pipe vertically between the mesh and the core at the points which will be the top and bottom of the pipe, and a 3-inch gas pipe in the same manner at the

sides. This gives the mesh the desired position of ¾-inch from the inner face at the top and bottom and ¾-inch from the outer face at the sides. The pipes are removed during concreting. Since the shell has been closely made to dimensions in the reinforcement shop, it is perfectly rigid when the pipes have been inserted.

Two men work continuously on the shells in the reinforcement shop. The bars and expanded metal are delivered to dimension from the mills. The bars for the hoops are first bent to the proper radius in a set of rolls, and are then laid around a steel hoop, drawn tight, and the ends wired together. A set of the hoops is then hung on a stick of wood on trestles, notched so as to give the correct spacing, and the longitudinal bars wired on. Care is taken to break joints in setting the hoops. The shell is then ready to be placed in the mold. The bell ends are bent and bell hoops put on after the body of the pipe has been concreted, so that there is no interference with concreting and tamping.

In shaping the expanded metal shells a sheet is laid flat and shaped against a cleat on the floor, bending being against the grain, as explained. A couple of wire hoops of proper diameter are placed around the shell and the two ends of the expanded metal wired together. The 18-inch pieces of corrugated bar are then wired on at one end for the bell.

After the reinforcing shell has been wedged in place around the core on the assembling platform, the outer shell sections are placed by the derrick, and bolted and bound together. The steel lugs on the car floor also guide and hold these sections in place. The core centers for the bell are put on the car and the car pushed to the mold track, which is outside the curing house and leads to the molding shed at the west end of the yards. Two men are required to assemble the forms, in addition to the men at the hoist. All inner faces of the molds are oiled before assembling.

The molding shed is elevated about 8 feet from the ground, so that the men may work handily in the tops of

the molds, which are run under the shed on their cars. Concrete is mixed just below this shed in a ¾-yard open-drum mixer, which is proving very efficient. The concrete is proportioned 1 cement to 4½ screened gravel passing a 1-inch mesh, and is mixed wet. The mixer delivers to a shallow wooden skip, which is lifted by a derrick to the molding shed, where two men shovel the concrete into the mold and tamp it. About one-third yard is delivered in each batch, so as to permit of thorough tamping in sections in the mold. Tamping is done with long steel rods. The body of the pipe is first completed, the bars then bent and arranged in the bell, the bell core fastened on and the bell filled. About three charges are used in the smallest pipe, four in the second size and five in the largest. The volume of concrete in the three sizes is, respectively, 24, 33 and 41 cubic feet. Gravel for the concrete is obtained from a pit on a siding about half a mile distant, which furnishes gravel for concrete on a large part of the Burlington system. The deposit is exceptionally clean, well-graded gravel. It is taken out by a clamshell excavator. That used at the pipe plant is screened on a platform beside the mixer.

When the casting of the pipe is completed it is marked with the date, and the car bearing it is run into the curing house, which is 32 feet by 100 feet, containing three tracks of 12 cars capacity each. One track is usually devoted to each size of pipe for ease of handling. The purpose of this house is to provide a place where the pipes may be allowed to set in winter, rather than to provide rapid curing. It is lined with paper and equipped with steam coils. The temperature in winter is kept between 60 and 70 degrees, and in the summer the doors are left open for circulation of air. Steam is supplied in winter from a locomotive boiler in an adjoining shed. This boiler also supplies the mixer and concrete hoist engines through underground pipes, but in summer it is shut down and the engines run by the hoist boiler.

Newly cast pipes enter the west end of the curing house and come out of the east end when sufficiently set. They

are then run to the same platform where the molds were assembled, for removal of the molds. The molds are never removed in less than 48 hours. At the platform the filled mold is lifted from the car by the derrick and laid on its side. The outer top section is then unfastened and lifted off, the core wedges knocked out and core removed. A piece of timber with bearing cleats on it is then run through the pipe and the pipe picked up from the lower section of the mold by it. The pipe is then swung over into the storage yards and deposited on runways of timber, on which it may be rolled to the further parts of the yards. The molds are then cleaned, oiled and assembled.

Pipes for shipment are picked up from the storage yard by the derrick and lowered onto flatcars on the main siding. Curved wooden seats are fastened to the floor of the flatcars to steady the pipes during transportation. Four men are usually employed in the loading of the pipes.

The plant normally employs about 16 men and has an average output of 225 pipes per month, or 9 pipes per day of mixed sizes.

During the summer of 1906 a number of pipe culverts were made by Mr. O. P. Chamberlain of the Chicago & Illinois Western Railroad and described by him in a paper before the Western Society of Engineers: He used the simplest form of pipe, a hollow cylinder whose bases are at right angles to its axis. These pipes were built of an inside diameter of 4 feet and an outside diameter of 5 feet, making the walls of the pipes 6 inches in thickness. These pipes, which resemble in shape the hollow clay tiles used for tile drains, have been placed in low embankments where their tops are but 18 inches below the under sides of the cross ties. They were simply placed end to end in shallow ditches conforming with the outside surface of the pipes as nearly as it could be done by picks and shovels and the back and top filling of the earth embankment thoroughly tamped around and above the

pipes. Thus far they have given satisfactory service under heavy freight traffic.

Forms are of wood, of ordinary wooden tank construction. The inner form has one wedge shaped loose stave which is withdrawn after the concrete has set for about twenty hours, thus collapsing the inner form and allowing it to be removed. The outer form is built in two pieces with heavy semicircular iron hoops on the outside, the hoops having loops at the ends. When the two sides of the outer form are in position, the loops on one side come into position just above the loops on the other side, and four steel pins are inserted in the loops to hold the two sides together while the form is being filled with concrete and while the concrete is setting. After the inner form has been removed, the two pins in the same vertical line are removed and the form opened horizontally on the hinges formed by the loops and pins on the opposite side. The inner and outer forms are then ready to be set up for building another pipe.

The concrete used in manufacture of these pipes was composed of American Portland cement, limestone screenings and crushed limestone that had passed through a ¾-inch diameter screen, after everything that would pass through a ½-inch diameter screen had been removed. The concrete was mixed in the proportions of 1 part cement to 3½ parts each of screenings and crushed stone. All work except the building of the forms was performed by common laborers. The cost of these pipes built under these conditions was $2.50 per lineal foot. This high price was due, in part, to the small scale on which the work was carried on, and amounts to $9.62 per cubic yard for the cost of concrete. It should be possible to manufacture these pipes in quantities, using enough forms to keep one or two laborers steadily at work, for $7 per cubic yard, including the cost of forms. This is equivalent to $1.83 per lineal foot of 4 feet inside diameter concrete pipe. The cost of the lightest cast iron pipe of the same diameter is $19.50 per lineal foot.

The following table shows comparative weight and cost of concrete and "Standard" cast iron pipes from 1 foot

up to 4 feet in diameter; it is based on the above price of \$7 per cubic yard for concrete and 3¼ cents per pound for cast iron pipes.

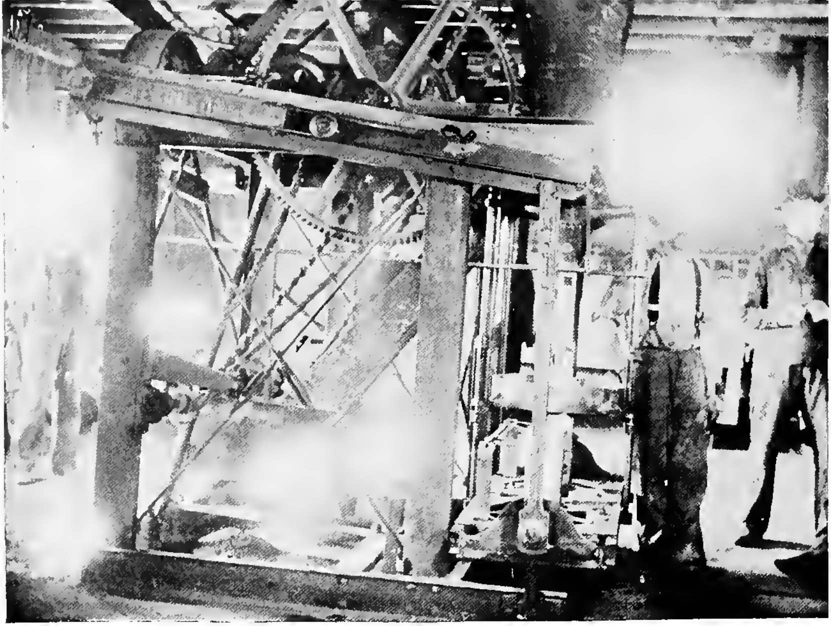
Table showing relative thicknesses, weights, and cost of Standard" cast iron pipe and concrete pipe.

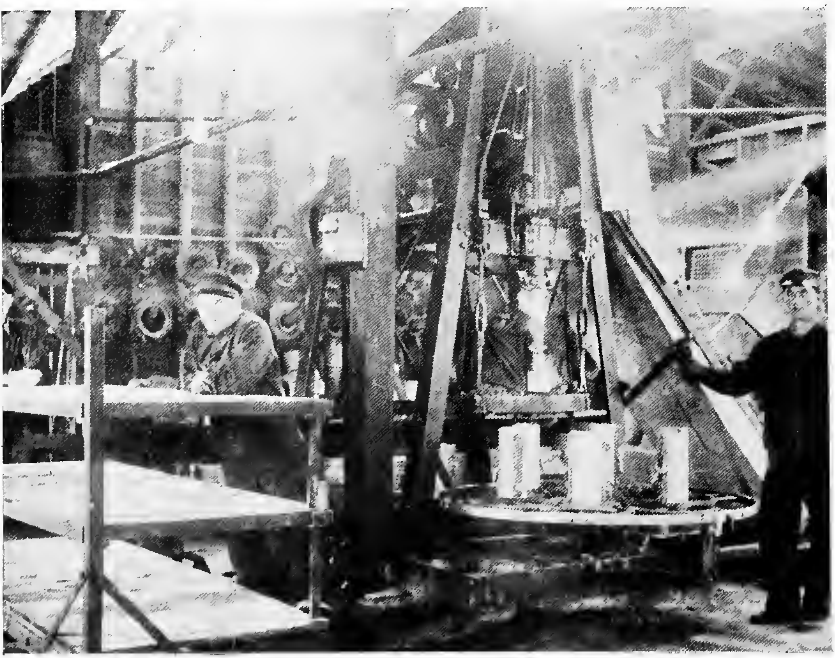
Size and kind of pipe—	Thickness in inches.	Weight lbs. per lin. ft.	Cost per lin. ft.
12 inches diameter, cast iron.....	0 33/64	75	\$ 2.44
12 inches diameter, concrete.....	2	88	0.16
18 inches diameter, cast iron.....	0 47/64	167	5.43
18 inches diameter, concrete.....	3	220	0.36
24 inches diameter, cast iron.....	1	250	8.13
24 inches diameter, concrete.....	4¼	420	0.68
30 inches diameter, cast iron.....	1 1/16	334	10.86
30 inches diameter, concrete.....	4½	602	0.88
36 inches diameter, cast iron.....	1⅛	450	14.63
36 inches diameter, concrete.....	4¾	676	1.10
42 inches diameter, cast iron.....	1⅜	600	19.50
42 inches diameter, concrete.....	5¾	960	1.55

In the above table the thickness for concrete pipes of various diameters have been taken as approximately proportional to the thickness of "Standard" cast iron pipes of the same diameter, the 4 feet diameter pipes being used as a basis for calculation.

The first cost of concrete pipes at the place of manufacture would, according to the above table, be less than one-twelfth of the cost of cast iron pipes. The cost of transportation and of installing the pipes would, on account of the greater weight and greater number of pieces, probably be very nearly double for concrete pipes, what the same service would cost for cast iron pipes.

On account of the lack of reliable data regarding this cost, Mr. Chamberlain was unable to give a fair comparative estimate of the cost of the two styles of culverts in place. However, since the transportation and installation of iron pipes is but a small proportion of the cost of the completed culverts, it is evident that cost of a concrete pipe culvert in place would be but a small fraction of the cost of a iron pipe culvert of the same diameter, provided the pipes were hauled only moderate distances.





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CHAPTER VI.

ESTABLISHING A PLANT.

The man who has in mind the establishing of a plant for the manufacture of any line of pipe and tile product must take two things particularly into consideration; (1) the possibility of securing a suitable supply of raw materials at a reasonable price; and (2) the market for the product which it is possible to develop.

The character of the materials which should be used is treated of in another chapter. Unless materials of this nature can be secured in the vicinity, or can be shipped in under unusually favorable conditions of delivery, the location of a permanent plant should not be considered. A temporary plant for the accomplishment of a particular piece of work can of course be located almost anywhere, the proximity to the work sometimes offsetting heavy delivery charges for materials; but for an ordinary commercial plant, which expects to continue in business year after year, it is necessary that the item of hauling be cut down as much as possible. The writer has seen plants which were apparently located on no other consideration than because of proximity to the owner's home, or because of the securing of a site at a very low figure. Materials had to be secured at some distance by team haul, and the finished product likewise had to be hauled too far to the railway station for rail shipments, while the location was not such as to attract attention and advertise the business.

Of course it sometimes happens that an excellent market is discovered in a locality where there are no materials of a suitable nature. In cases of this kind it is usually more economical to provide for delivery by rail, rather

than to try to locate a source of supply within teaming distance. The sidertrack can then be used for the delivery of cement as well as for the shipment of the finished pipe or tile. In fact there are few plants now being opened up which do not have direct connection with the railroad, and the design of the plant is so made that the materials of all kinds, as well as fuel, can be delivered from the track direct to the storage bins.

All the local conditions will need to be gone over thoroughly in order to determine the market probabilities for a plant. In the case of a plant for the manufacture of drain tile, this will include such considerations as the nature of the soil, whether adapted to improvement by tile drainage or not; the value of the land; the general prosperity of the people; their attitude with respect to improvements in farming, and their general attitude with reference to spending money; the feeling in the community, and especially among county or drainage district officers, with reference to cement products. All these things will not only influence one in determining a point for the establishing of a plant, but when such location is finally determined upon they will help the owner to decide what size the plant shall be and what investment he will be warranted in making.

In general it might be said that in this as in other lines of work it is usually best to work along the lines of least resistance. It is scarcely worth while to establish a plant where the sentiment is strongly adverse to cement, when there are so many good locations not yet occupied. The missionary work which would have to be done in such a location before one could get a business foothold, will be done sooner or later in the general spread of the knowledge of the advantages of cement, without tying up anyone's business investment in the meantime.

The establishing of plants for the manufacture of pipe for sewer and irrigation purposes, and the like, will depend very largely on the co-operation and general good will of public officials, and such are seldom undertaken, except in a small way, unless a market is already devel-

oped for a large part of the output. Pipe of this kind, except in very limited quantities, is not a general article of commerce, and is for the most part made only when the market is provided for it beforehand.

Mr. Powell's Suggested Design. In a paper before the Sixth Convention of the National Association of Cement Users, Mr. C. M. Powell, assistant inspecting engineer of the Universal Portland Cement Company, showed plans of a suggested design for a tile plant, which are here shown and concerning which he gave the following description:

The main part of the building is 50 by 75 feet and in this are located the office and tile making machines. The sand, gravel, coal and cement storage, engine and boiler rooms are in the lean-to between the main part of the building and the railroad siding. The curing chambers for the small tile are on the opposite side of the building and those for the large tile are in the rear. A row of windows placed under the eaves, together with the windows in the gable ends, will furnish sufficient light.

The walls of the building are made of concrete blocks, with the exception of the sand and gravel bins, which are monolithic concrete, reinforced. The roof of the lean-to and the roofs of the steam curing chambers are also of reinforced concrete. This type of roof has been selected as embodying more good qualities than any other. Owing to the conditions existing in the chambers, timber roofs last but a few years; besides, they are not fireproof. The roof of the main building is carried upon steel trusses which are supported by two rows of columns and the side walls. A concrete tile roof, although a little more expensive than some of the other kinds of roofs, should prove very satisfactory and last indefinitely.

The plan shows the interior arrangement of the plant. The mixing equipment is located directly in front of the sand and gravel bins, between the two tile machines, so that concrete may be delivered to either one or both of the machines. The small tile as made are placed on a car at the side of the machine and removed, a carload at a time, over the transfer track to any of the curing

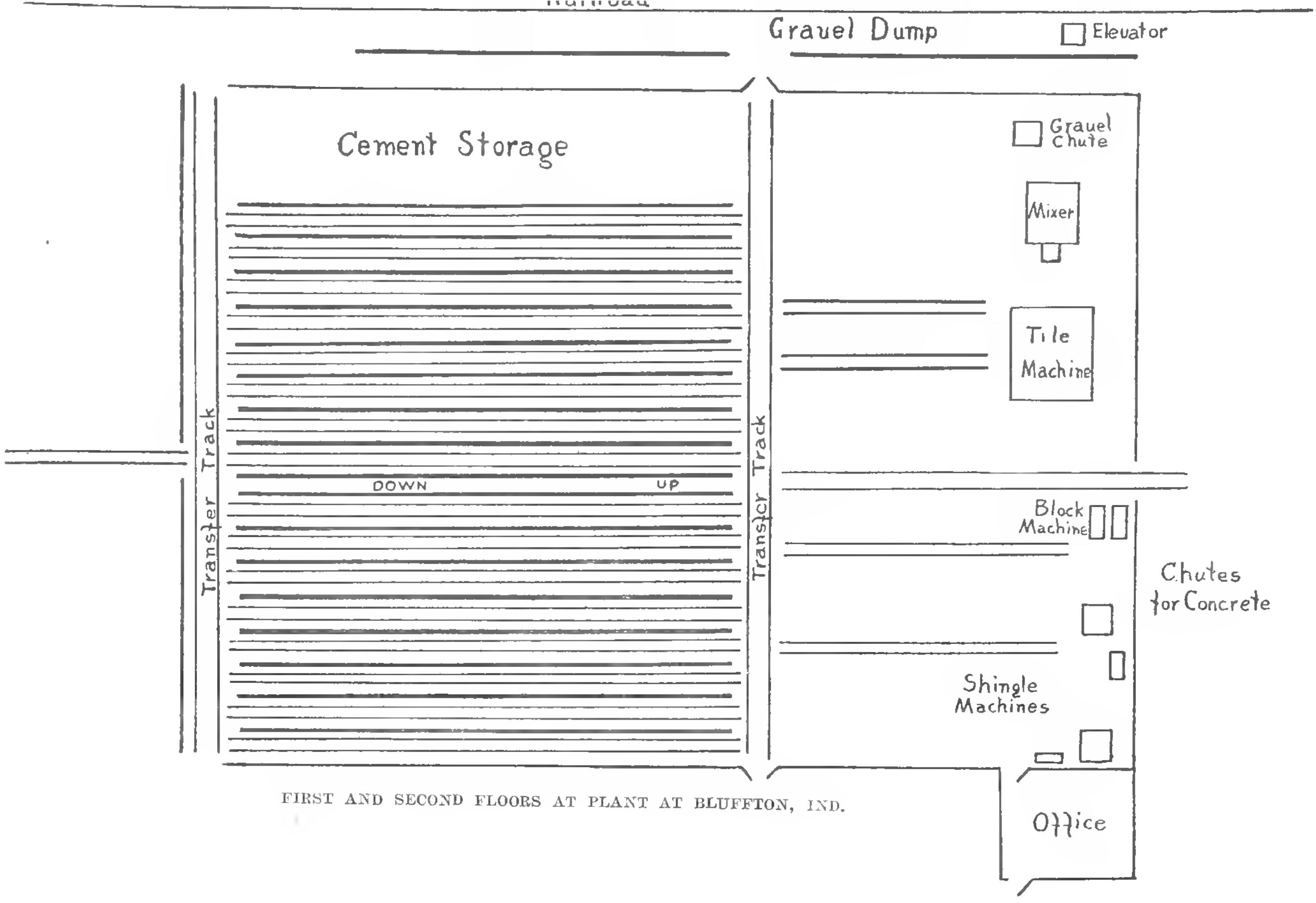
chambers. The curing chambers open onto a transfer track inside the building at the opposite end and by means of a transfer table the cars can be taken to the yard, through doors at the end of the track or through doors in the end of the building. The empty cars may be returned back to the machine by running them around on the track at the end of the yard or by being transferred.

The large tile are conveyed by two-wheeled cars directly from the machine to the curing chambers provided for them and are removed to the adjoining cars. As it is hardly possible to locate both the large and small tile storage yards next to the railroad track, it is advisable where only one siding is available, to store the large tile nearest the track, as the small tile are easily handled and most of them are sold to the local trade.

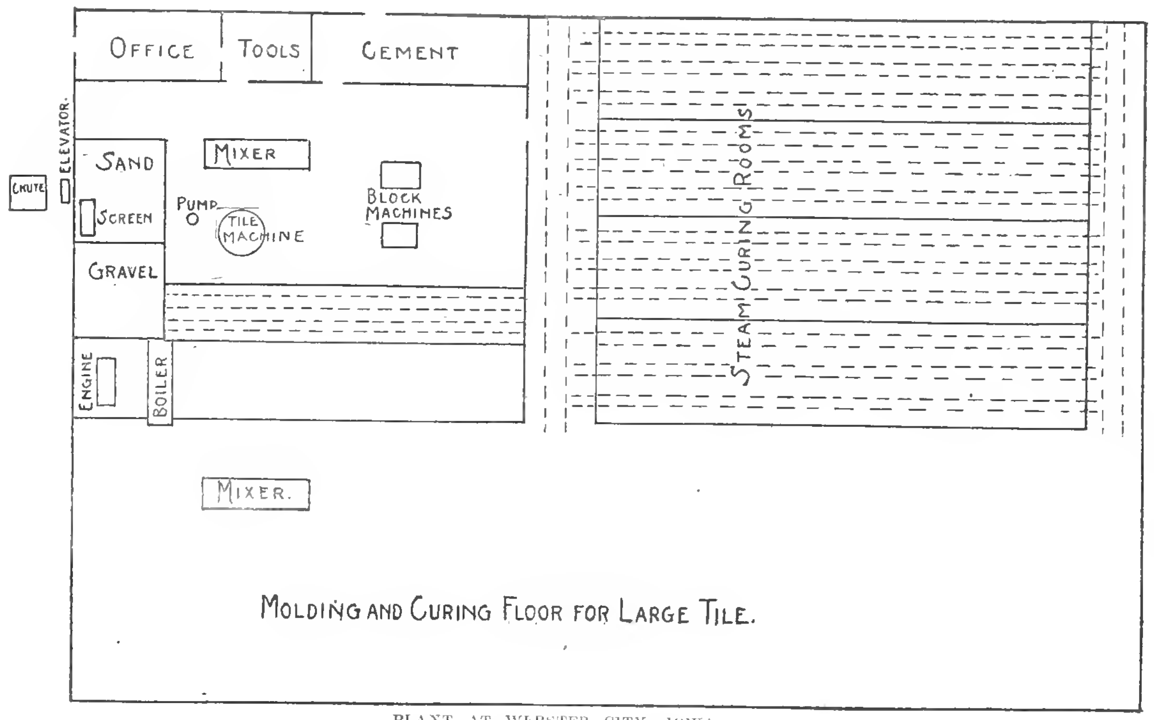
The entrance to the plant is located so that any one hauling tile must necessarily pass the office. The front entrance to the building, through which all help and others should be required to pass, is through the office, which facilitates time-keeping, etc.

In the main room an overhead platform provides a place for the extra jackets, packer heads, repairs and other accessories not in continual use, which may thus be gotten out of the way. A work bench around which there is enough space available for making such repairs as can be made at the plant, is placed directly under the overhead platform. The boiler and engine rooms are placed next to each other so that one man can be fireman and engineer. A dynamo is installed in the engine room to furnish light for the plant. A small steam engine is provided to run the dynamo as lighting is required mostly at night when the large engine would not be running.

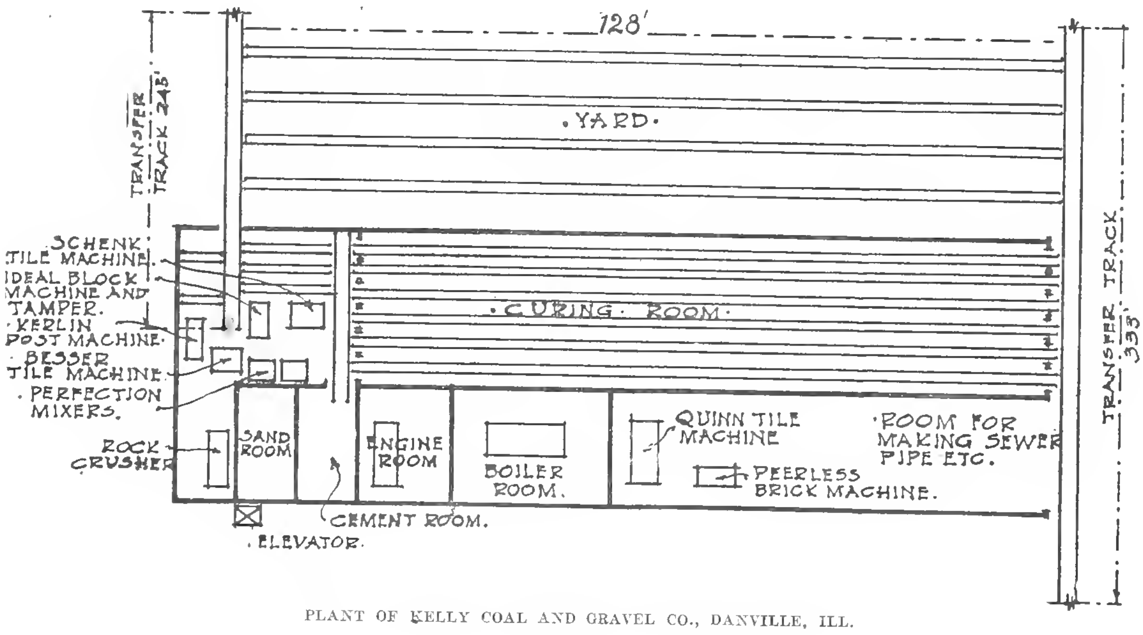
All the materials are delivered along one side of the plant, preferably by cars. The respective storage bins are separated from each other as much as possible to allow of "spotting" more than one car on the track at a time. The gravel is delivered by car or by wagon and



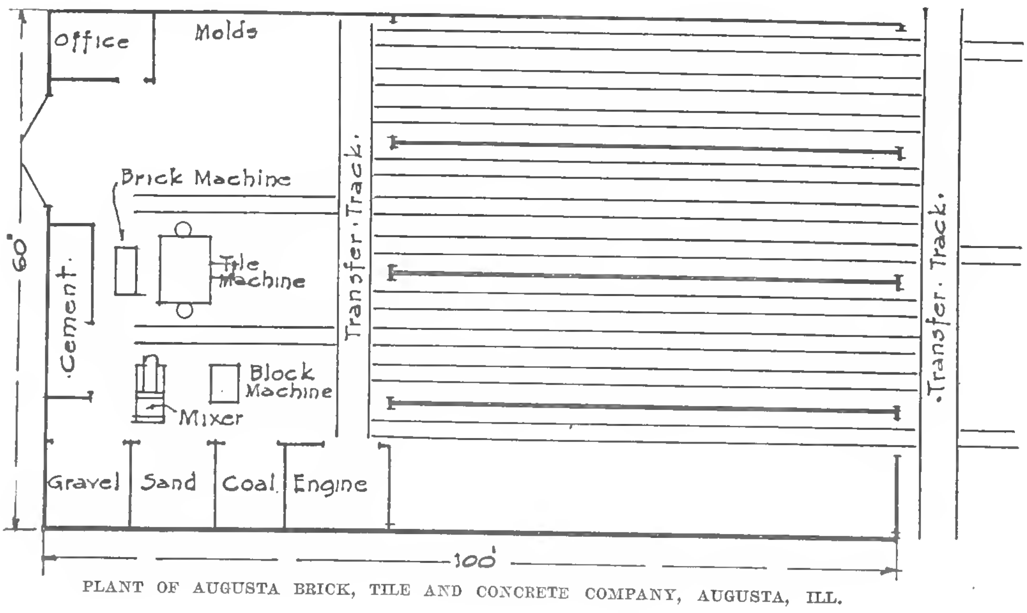
FIRST AND SECOND FLOORS AT PLANT AT BLUFFTON, IND.



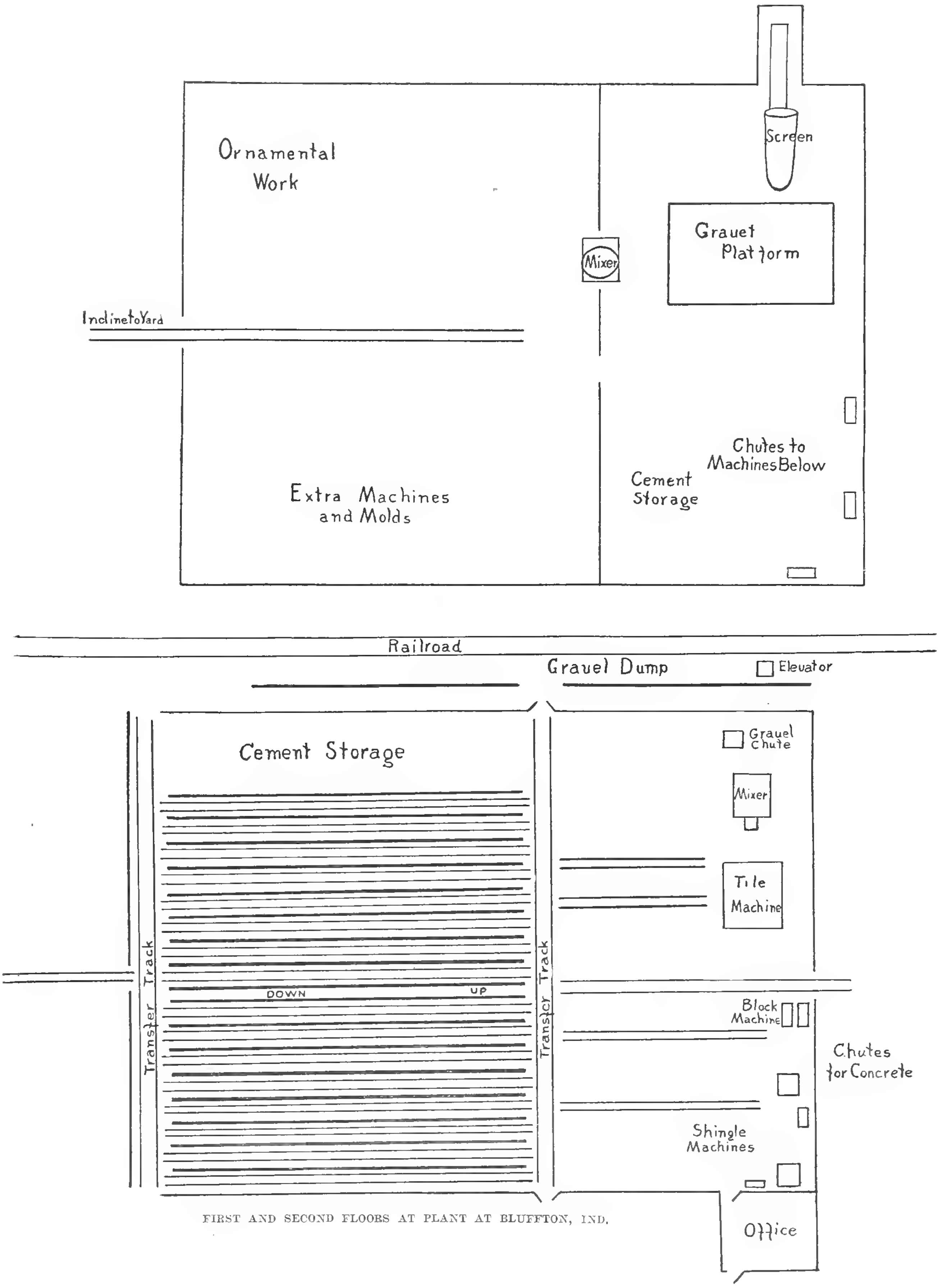
PLANT AT WEBSTER CITY, IOWA.



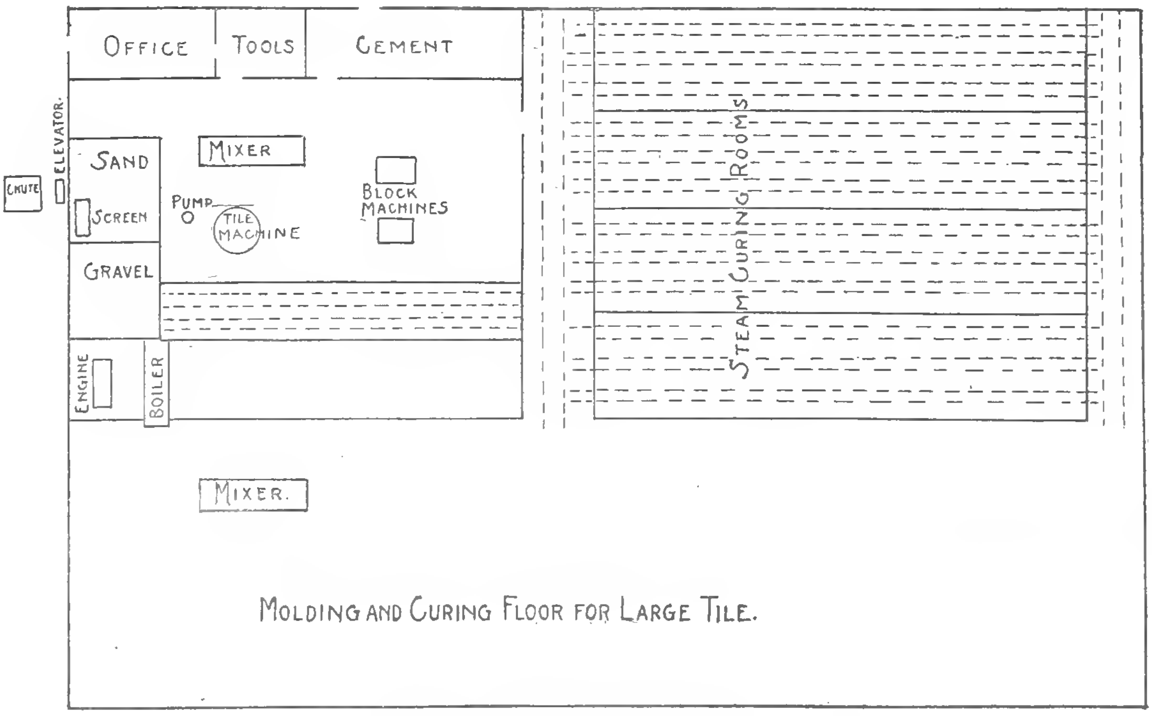
PLANT OF KELLY COAL AND GRAVEL CO., DANVILLE, ILL.



PLANT OF AUGUSTA BRICK, TILE AND CONCRETE COMPANY, AUGUSTA, ILL.



FIRST AND SECOND FLOORS AT PLANT AT BLUFFTON, IND.



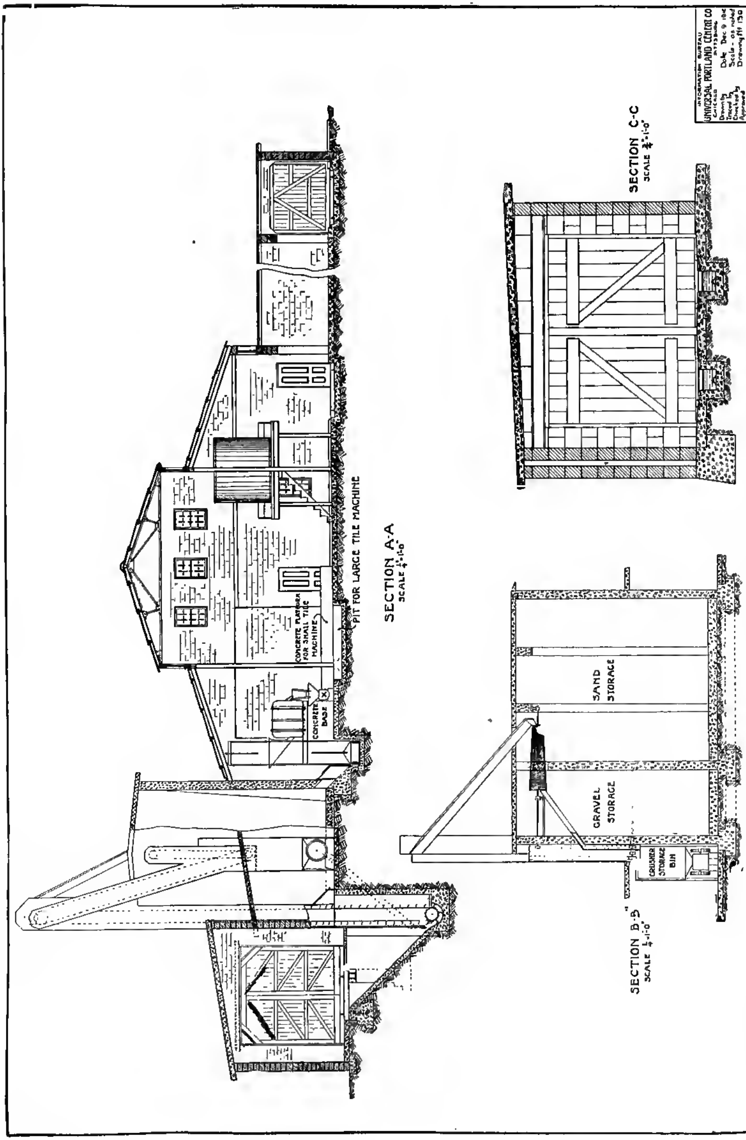
PLANT AT WEBSTER CITY, IOWA.

dumped directly into the track hopper, from which it is elevated to the screen over the sand and gravel bins. A gravel bin is provided because it is not economical to make all the sizes of tile with the same aggregate. The sloping sides and bottom of the track hopper delivers all the material to the elevator, which carries the material high enough to spout it over the top of the storage bins to the rotary screen. That part of the material smaller than three-quarters of an inch in diameter passes through the screen and into the sand bin while that larger than three-quarters of an inch and less than half an inch in diameter falls into the gravel bin.

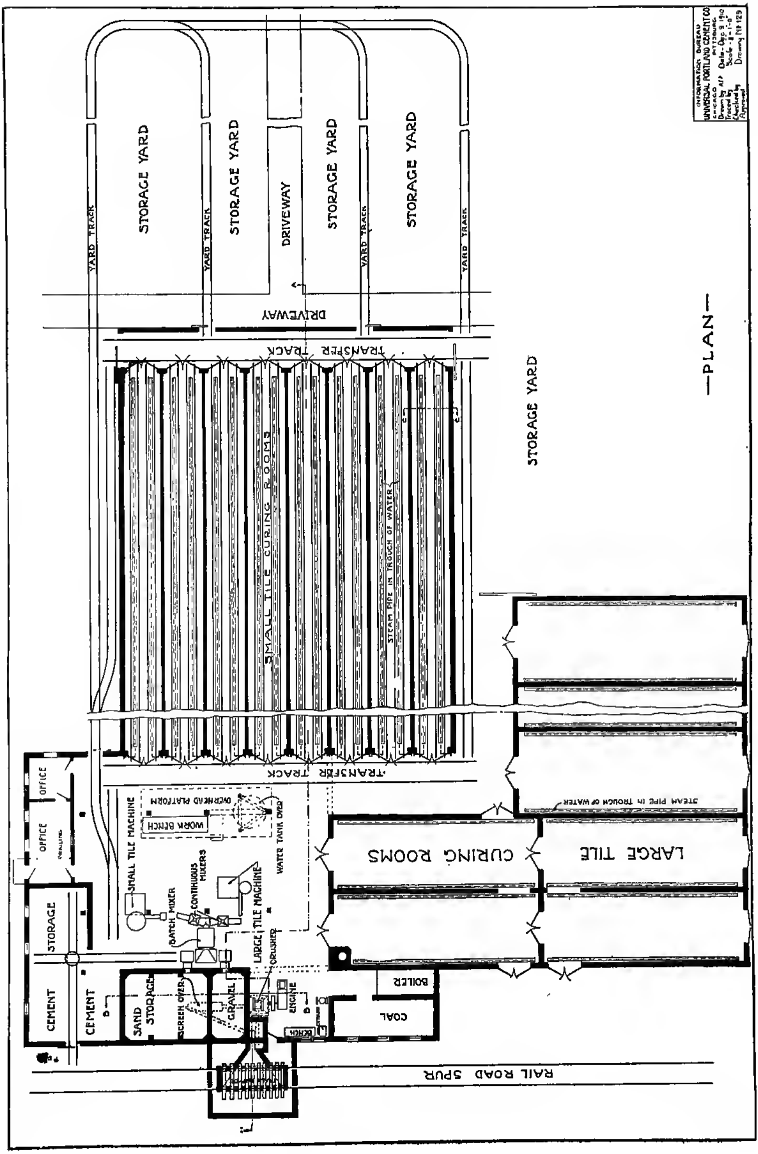
All the coarser material is discharged from the lower end of the screen into a chute leading to a small hopper over the crusher, which is placed at the end of the bin. The crusher is set to reduce the materials to about half an inch and discharges the crushed gravel into the elevator, which returns it to the screen.

The bottom of the bins are not hoppered or elevated, which allows of additional storage capacity, and the "dead" supply may be shoveled in case the material is required. The aggregates are drawn from the bins through an opening in the side at the floor line into a measuring chute. The flow is controlled by an under-cut gate placed at the opening in the bin. When the measuring chute is filled the under-cut gate is closed and the charge is allowed to pour out into the loading skip by opening the gate in the lower end. The cement for the batch is placed in the skip with the sand, which is then hoisted and the materials dumped into the hopper of the batch mixer, where they are mixed dry. The mixed dry batch is then discharged into a hopper which feeds uniformly into a pug for wet mixing, and as the feed to the pug is practically uniform, the consistency of the mixture can be easily controlled. One man should be able to run the batch mixer, as the only material which he has to actually handle is the cement.

To operate the suggested plant to full capacity on all sizes of tile will require a foreman and about twenty



SECTIONAL VIEW OF PLANT SUGGESTED BY MR. POWELL.



PLAN OF SAME PLANT.

men distributed as follows: One engineer, one man running the mixer, one man feeding each tile machine and one operator on each machine, one man removing jackets from small tile, one handling cars and four yardmen who remove the tile to the yard, load wagons and do odd jobs about the plant when not otherwise engaged; two men will always be needed wheeling the large tile from the machine and sometimes three, one man removes the jackets, and two men, with the help of the one man sometimes used for wheeling tile, can remove the tile to the yard, load wagons and cars; a night man will be required to keep up steam, clean, repair and change the machines.

CHAPTER VII.

The Materials Required.

As has been suggested in another part of this book, the comparatively thin walls of concrete pipe and tile, the weight of earth which they have to hold up, and in some cases the internal pressure which they are called upon to sustain, make it imperative that the materials which enter into such products be of the very best. In a large mass of concrete, a lump of clay or other impurity will not appreciably affect the strength of the mass, for it will be surrounded by concrete of a better grade; in pipe and tile, however, a lump of this kind might extend through the thickness of a pipe wall from one side to the other and cause serious trouble. The same will hold true to a greater or less degree for all impurities in materials, or for failure to grade them properly—the slightest variation having an influence on the strength of the finished product.

Cement. It is perhaps sufficient to say for the cement which enters into the composition of pipe and tile that it should meet the requirements of the standard specifications for Portland cement of the American Society for Testing Materials. As these specifications are required on practically all work, all cements now manufactured are supposed to conform to them; and they usually do, unless there should be some defect in manufacture in a particular lot, or the cement should have encountered adverse conditions after leaving the mill. The majority of manufacturers of these products accept the mill test of the cement as final, although in some cases the purchaser engages a laboratory to test the cement from the car, and in a few instances manufacturers or contractors have their

own laboratory apparatus for making more or less exhaustive tests.

The time of setting is of course easily tested. The cement should not develop initial set in less than thirty minutes, and should develop hard set in not less than one hour nor more than ten hours. Neat cement briquettes should show a tensile strength at seven days of not less than 150 pounds, and at 28 days of not less than 550 pounds. Briquettes made of a 1:3 mixture of cement and sand should have the same strength at 7 days and a strength of not less than 200 pounds at 28 days. The tests for fineness and specific gravity require laboratory apparatus, but they are important, especially the fineness test, as the complete crystalization and consequent strength of the product will depend in great measure on the fineness to which the cement is ground.

Aggregates. The aggregates should be of clean, hard, durable material, and should have no coating of clay or other substances which would in any way interfere with the bond between the cement and the aggregate.

The fine aggregate should consist of sand or crushed stone, graded from fine to coarse, but all of it passing a screen having ¼ inch holes. It should be free from vegetable loam or other deleterious matter; and briquettes made with this fine aggregate and the cement to be used, in the proportion of 1 to 3, the briquettes to be made in conformity with the Standard Specifications of the American Society for Testing Materials, should show a tensile strength of not less than 150 pounds per square inch at 7 days, and not less than 200 pounds at 28 days. It is usually specified that not more than 6 per cent should pass a screen having 100 meshes to the inch. Mr. George P. Dieckmann, chief chemist of the Northwestern States Portland Cement Company, at one time conducted an extensive series of tests to determine the best grading of materials from cement tile, and arrived at the conclusion that not more than 10 per cent should be retained on a 10-mesh sieve, nor more than 30 per cent pass a 50 mesh sieve.

The coarse aggregate should consist of gravel or crushed stone, free from deleterious materials; it should be graded in size, but all of it should be retained on a screen having holes ¼ inch in diameter, and none of it exceed in greatest dimension one-half the wall thickness of the tile in which it is to be used.

Water. The water should be clean and practically free from organic matter, sewage, oils, acids or alkalis.

Amount of Water. Enough water should be used so that on both hand and machine-made tile, web-like markings will appear on the surface when the forms are removed. The consistency of concrete for slush tile should be that of thin mortar which can be forced to any part of mold by slight churning.

Proportioning Materials. The use of fine aggregate only, mixed with the cement in the proportion of 1 to 3, is recommended as being safest for all tile up to 10 inches in diameter. Where two sizes of aggregate are used, they should be tested for the actual voids contained therein, and should be so proportioned that the cement should over-fill the voids in the fine aggregate by at least 5 per cent., and the cement and fine aggregate should over-fill the voids in the coarse aggregate by at least 10 per cent.

Amount of Materials. Many plants do not keep accurate account of the materials entering into each of day's run, or each 1,000 units of product, though it would be much better if this were always done. At points where this is carefully accounted, slight variations will occur from day to day, due to inaccuracies of measurement, variations in materials, or lack of uniformity in manufacturing conditions. Greater variations will be observed between the figures from different plants. Probably sufficient data is not available on which to base a positive statement, but it would seem that widely separated plants, using materials of greatly differing qualities, show the greatest differences, and leading to the inference that variations are the result largely of differences in the materials themselves, rather than in manufacturing conditions. The grading of the

fine and coarse particles of aggregate will cause the larger part of the variation, though different cements will show a tendency to slight variations in bulk when water is added to them. The instances here given will enable one to strike an average as to materials.

Daily Record of 5 and 6-inch Tile. An Indiana manufacturer takes the following from his daily records for a number of successive days, the runs being on 5-inch tile made in proportions varying from 1:4½ to 1:5:

June	15—	3,000	5-inch	tile;	used	51	sacks	cement
"	22—	3,000	5	"	"	"	52	"	"
"	23—	3,000	5	"	"	"	48	"	"
"	27—	3,200	5	"	"	"	52	"	"
July	1—	3,350	5	"	"	"	54	"	"
"	2—	3,400	5	"	"	"	54	"	"
"	3—	2,900	5	"	"	"	42	"	"
"	6—	3,000	5	"	"	"	46	"	"
"	7—	3,000	5	"	"	"	42	"	"
"	31—	3,200	5	"	"	"	47	"	"
Aug.	1—	2,660	5	"	"	"	38	"	"
Sept.	9—	3,150	5	"	"	"	48	"	"
12 days,		26,860	5	"	"	"	574	"	"

This works out to an average of slightly less than 16 sacks of cement per 1,000 tile.

The same manufacturer gives the following figures on 6-inch tile, which work out to an average of 20.3 sacks of cement per 1,000:

April	13—	2,300	6-inch	tile;	used	56	sacks	cement
"	14—	2,300	6	"	"	"	55	"	"
"	16—	2,600	6	"	"	"	66	"	"
May	1—	2,500	6	"	"	"	49	"	"
July	8—	3,300	6	"	"	"	57	"	"
"	14—	2,900	6	"	"	"	59	"	"
"	15—	3,000	6	"	"	"	55	"	"
"	28—	2,900	6	"	"	"	60	"	"
Aug.	14—	2,600	6	"	"	"	52	"	"
"	31—	2,700	6	"	"	"	51	"	"
Sept.	12—	3,100	6	"	"	"	54	"	"

"	16—	2,948	6 "	"	"	50	"	"
12 days,		33,148	6 "	"	"	664	"	"

Tile from a Yard of Sand. Some manufacturers choose to reverse their manner of reckoning and make a record of the number of tile made from a yard of sand or a given amount of cement. From the records of an Iowa plant we take the following, based on a 1:4 mix:

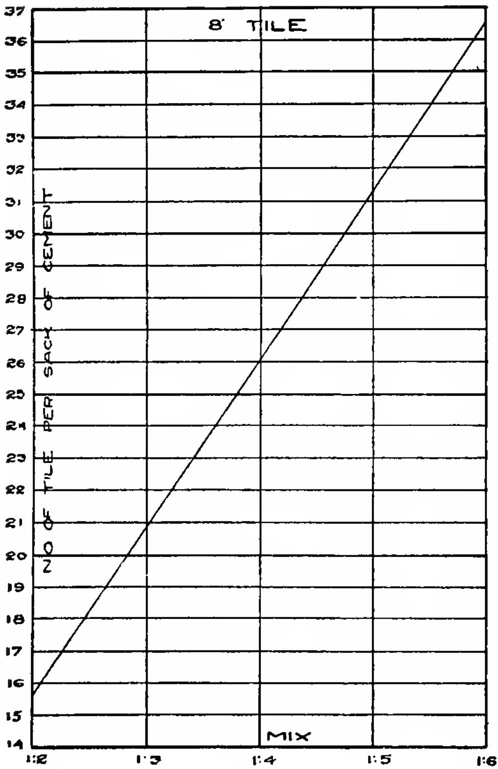
1 yard of sand makes 340 tile 4 inches in diameter
1 yard of sand makes 275 tile 5 inches in diameter
1 yard of sand makes 240 tile 6 inches in diameter
1 yard of sand makes 175 tile 7 inches in diameter
1 yard of sand makes 150 tile 8 inches in diameter
1 yard of sand makes 90 tile 10 inches in diameter
1 yard of sand makes 65 tile 12 inches in diameter

On 44-inch Pipe. On an extensive drainage job in Iowa, 44-inch pipe was made in 3-foot sections on an automatic power machine. The pipes were made with 4-inch walls, each section requiring 1 barrel of cement and 1,200 pounds of sand.

Materials on Large Sizes. The following figures are for materials to make 1,000 feet of the sizes indicated, and are based on figures compiled by the Quinn Wire & Iron Works, Boone, Iowa:

Diam.	Thickness						
14	1¼	178	sacks	cement	20	yards	sand
15	1¼	214	"	"	24	"	"
16	1½	267	"	"	30	"	"
18	1¾	417	"	"	47	"	"
20	1¾	550	"	"	62	"	"
22	2	700	"	"	80	"	"
24	2	937	"	"	105	"	"
26	2⅛	1062	"	"	120	"	"
28	2¼	1428	"	"	157	"	"
30	2½	1960	"	"	220	"	"
32	2½	2186	"	"	243	"	"
36	3	3500	"	"	388	"	"

Tile per Sack of Cement Shown Graphically. This curve, which was devised by Mr. J. H. Libberton of the Universal Portland Cement Company to show the tile per sack with various mixtures, has been figured on the assumption that the amount of cement in a tile can be determined from its weight, if the mixture is known. For instance, a tile weighing 20 pounds made with a 1:4



mixture would contain an amount of cement equal to ⅕ of its weight, or 4 pounds. To find the tile per sack it is only necessary to divide the weight of a sack of cement, approximately 94 pounds, by 4, which gives 23½ tile per

sack. In calculating the tables and plotting the resulting curves the average weight as determined in twelve tile factories was taken. The same method can be pursued in plotting the production of other sizes.

A Machine Manufacturer's Figures. The XL-All Manufacturing Company, Chicago, gives the following quantities for 1,000 tile of the different diameters with a 1:4 mix:

diameter	thickness	yds. sand	bbls. cement
4 inch	1/2	2.08	3.52
5	9/16	2.53	4.29
6	5/8	3.52	4.80
7	11/16	4.46	7.54
8	3/4	5.52	9.32
10	7/8	7.48	12.62
12	1	10.42	17.60

For 12 and 18-inch Lengths. The following figures are given by the Cement Tile Machinery Company, Waterloo, Iowa, as being the result of actual tests made by manufacturers, with a 1:4 mix:

Material Table for Tile 12 Inches Long.

Size	Cement	Sand	No. of Tile
4-inch	3 1/4 bbls.	2 yards	1,000
5-inch	4 1/2 bbls.	2 1/2 yards	1,000
6-inch	6 bbls.	3 3/4 yards	1,000
7-inch	7 1/2 bbls.	4 1/2 yards	1,000
8-inch	9 bbls.	5 1/2 yards	1,000
10-inch	12 1/2 bbls.	7 yards	1,000
12-inch	17 1/2 bbls.	10 1/2 yards	1,000

Material Table for Tile 18 Inches Long.

Size	Cement	Sand	No. of Tile
10-inch	20 1/2 bbls.	10 1/2 yards	1,000
12-inch	30 bbls.	15 3/4 yards	1,000
14-inch	41 bbls.	21 yards	1,000
16-inch	50 bbls.	29 yards	1,000
18-inch	66 bbls.	38 yards	1,000

Canadian Figures. Experiments at the Ontario Agricultural College, as reported by Prof. Wm. H. Day, show the following materials necessary for 1,000 tile:

Size	Proportions	Cement	Sand
3 inch	7 to 1	6.5 bags	1.7 yards.
3 "	6 to 1	7.6 "	1.7 yards.
3 "	5 to 1	9.1 "	1.7 yards.
3 "	4 to 1	11.4 "	1.7 yards.
3 "	3 to 1	14.0 "	1.6 yards.
4 "	4 to 1	15.1 "	2.2 yards.
5 "	4 to 1	20.0 "	3.0 yards.
6 "	4 to 1	22.7 "	3.4 yards.

Amount of Fuel Required. A plant with sufficient power capacity to run a tile machine, mixer and screen will use from 5 to 8 gallons of gasoline per day, or about one-half ton of a fair grade of bituminous coal.

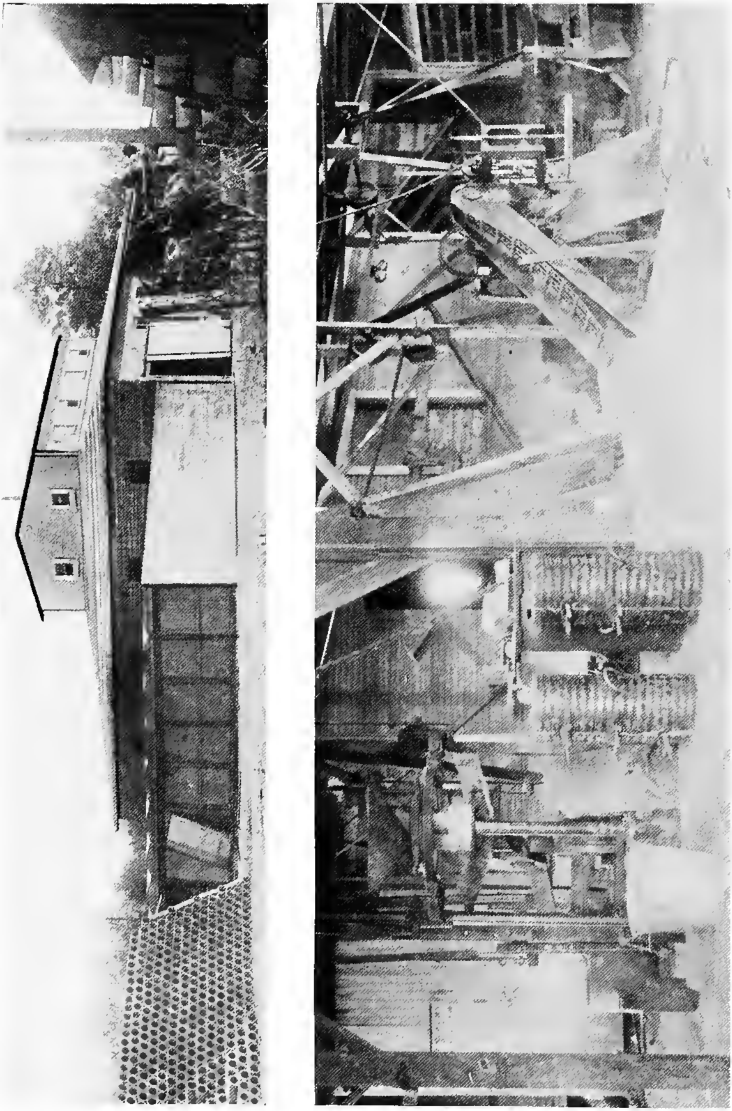
CHAPTER VIII.

Methods of Manufacture.

Two Methods Contrasted. The manufacture of cement pipe and tile may be carried on either in a plant especially prepared and equipped for the purpose, or may be prosecuted at or near the site of the place where the product is to be used. Both of these methods have apparent advantages to recommend them. Where the product is made in a plant especially equipped for the purpose, it can be kept under the control of the manufacturer better than in any other way, and of course machinery can be used which it would be impracticable to move from place to place. The particular advantage of the local method of manufacture is that the item of transportation is eliminated. Labor conditions are sometimes also more advantageous for this method.

In general it may be stated that the former of these methods is adapted primarily to machine manufacture while the latter lends itself readily to the use of hand molds; the former will therefore be used almost exclusively for small sizes while the latter will confine itself for the most part to the larger sizes. This is of course only a general classification; for there are machines on the market which make a special feature of their portability, while on the other hand there are power machines for making large sizes of pipe which can be used only in stationary plants.

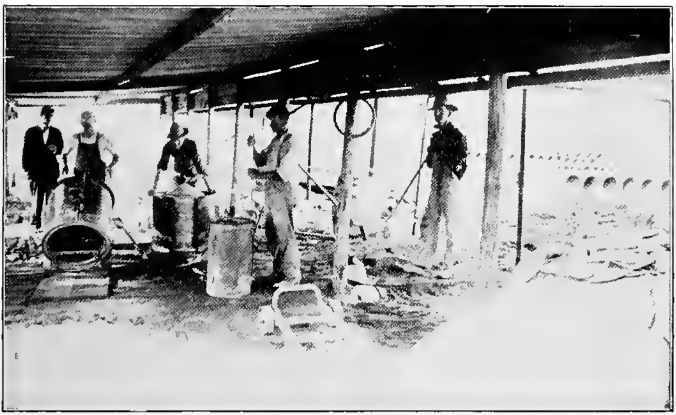
The writer is opposed to the manufacture of a dry-mix product in any other way than in a plant properly equipped to take care of it. He has seen so much of this class of product left exposed to the sun and wind, and with an amount of sprinkling which would be scarcely



VIEWS OF TWO PLANTS.

sufficient in an enclosed room, that he feels warranted in making a sweeping declaration against this method of manufacture.

Under the dry-mix method, the molds are removed immediately, thus exposing the product at once to the elements. Where a slush mix is used, and the pipe is left in the molds for a time, the work can be prosecuted along the trench with very good results. This method is employed especially on large reinforced pipe, and for this kind of work has some advantages. With pipe of this kind, transportation is a large item in the cost; and the manufacture of such pipe in a plant is very apt to congest conditions in the plant, unless it is built especially



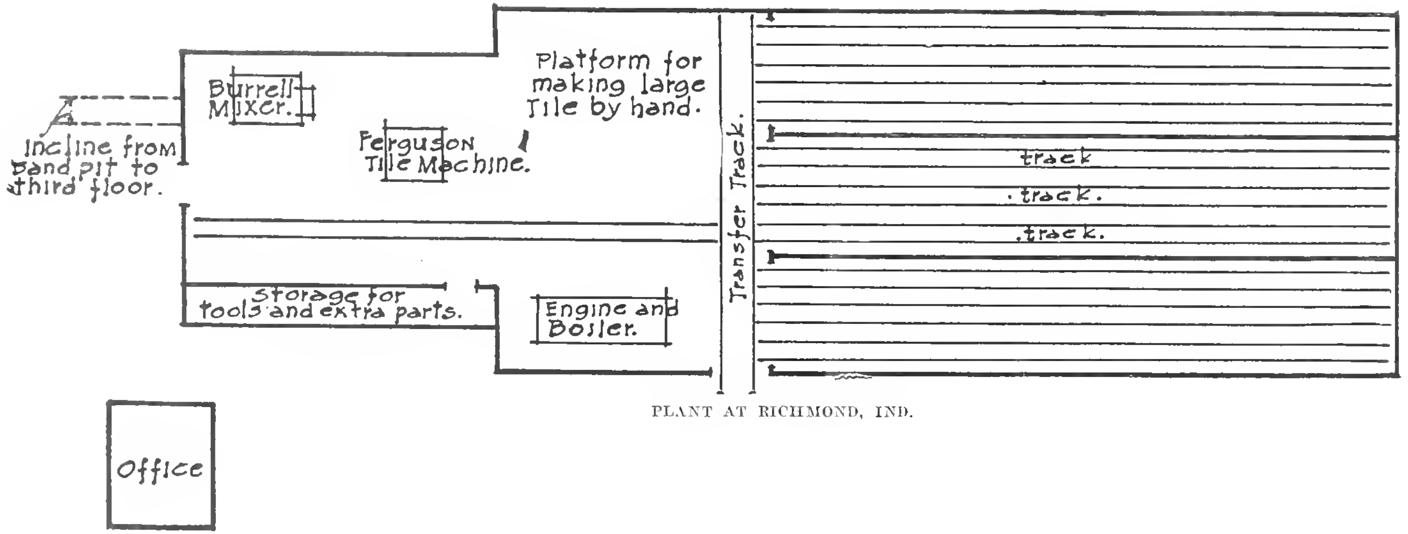
MAKING PIPF ON THE JOB.

for this class of work. A pipe which is reinforced can also be handled and placed sooner after its manufacture than a dry-mix product without reinforcing. The tendency seems to be, however, to concentrate the manufacture of even the larger sizes in well equipped plants wherever possible, and the fact that machine manufacturers are developing larger machines for this class of work will tend more and more to throw the balance of the economy in the direction of the plant-made product.

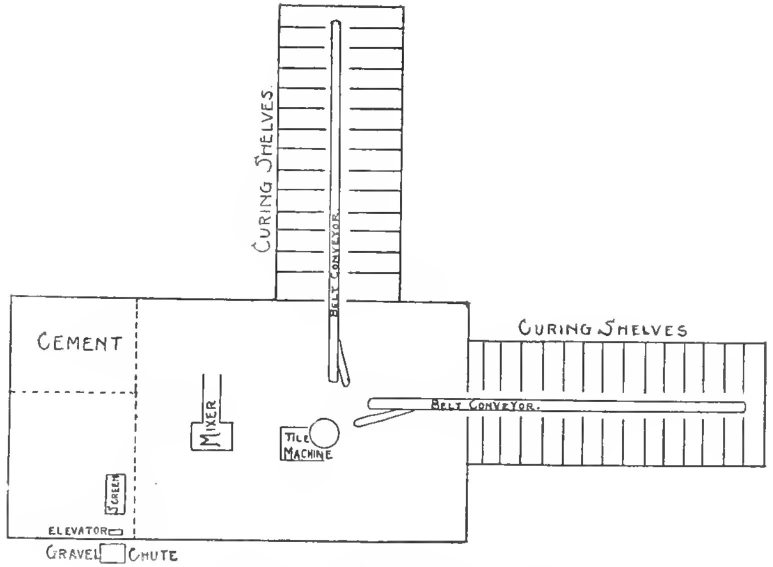
Two Types of Machines. Machines for pipe and tile manufacture may be broadly divided into two classes: The machines in which the packing is done by a revolving packer which works up and down inside the pipe, packing the concrete into an outside shell, and that type which has a mold with both outer and inner sections, the machine having automatic tamping devices working between the two sections to pack the concrete, much after the fashion of hand tamping. The former of these is, broadly speaking, better adapted to the making of small pipe and tile, and the latter to the larger sizes, although they overlap each other in a number of the intermediate sizes. All of the machines now on the market will be found described in detail in Chapter XII.

In selecting a machine, the choice will be governed very largely by the extent and character of the probable business to be developed. If the possibilities lie largely along the line of small drain tile, and a large market for this product is possible of development, the equipment will naturally be different from that in a locality where there are possibilities for the sale of large sizes of pipe draining flooded areas or for the irrigation of barren soil. Again, if a market is in sight for concrete sewer pipe, the equipment will take still another trend. The size and cost of the equipment selected will of course be governed by the market, so far as that market can be determined in advance.

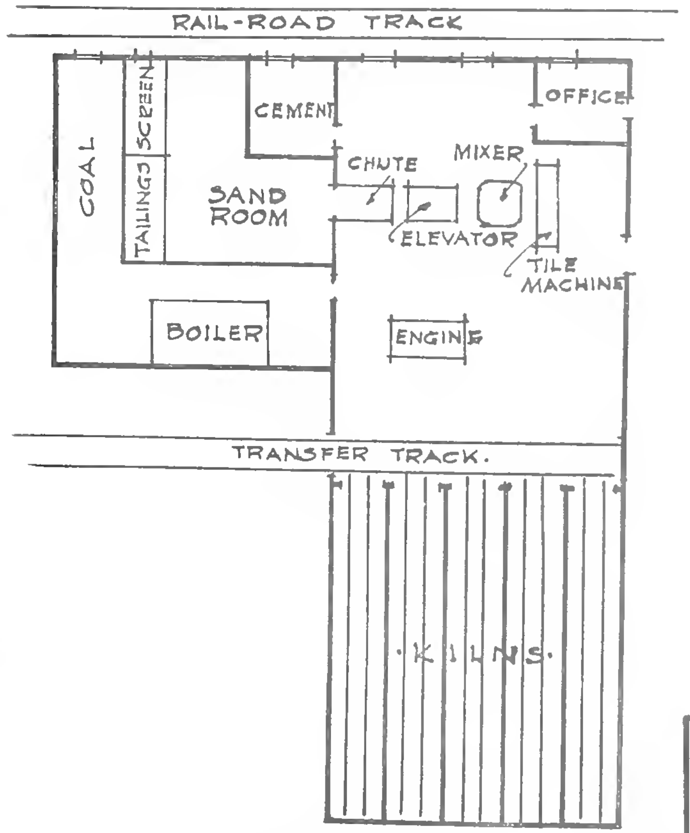
Almost every machine on the market has particular features which adapt it better than any other to some particular line of work. Where the business will warrant it, therefore, a plant equipped with two or more machines, each kept busy on the line of work for which it is best suited, is the ideal plant. The writer hopes at some time to see a plant equipped with a half dozen or more machines, each working on a specialty of its own. With an equipment of this kind the unit cost would be greatly reduced; but the drawback to such a plant would be that the output would be so great as to supply the total available market in a short time, unless one undertook to



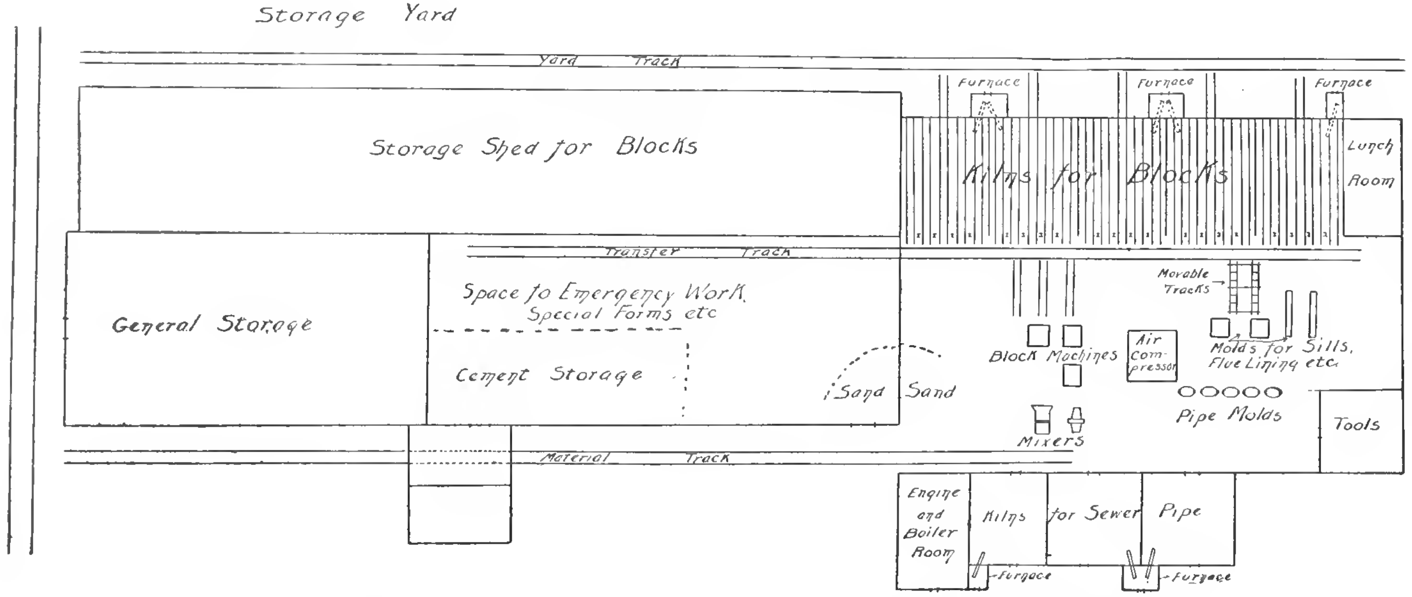
PLANT AT RICHMOND, IND.



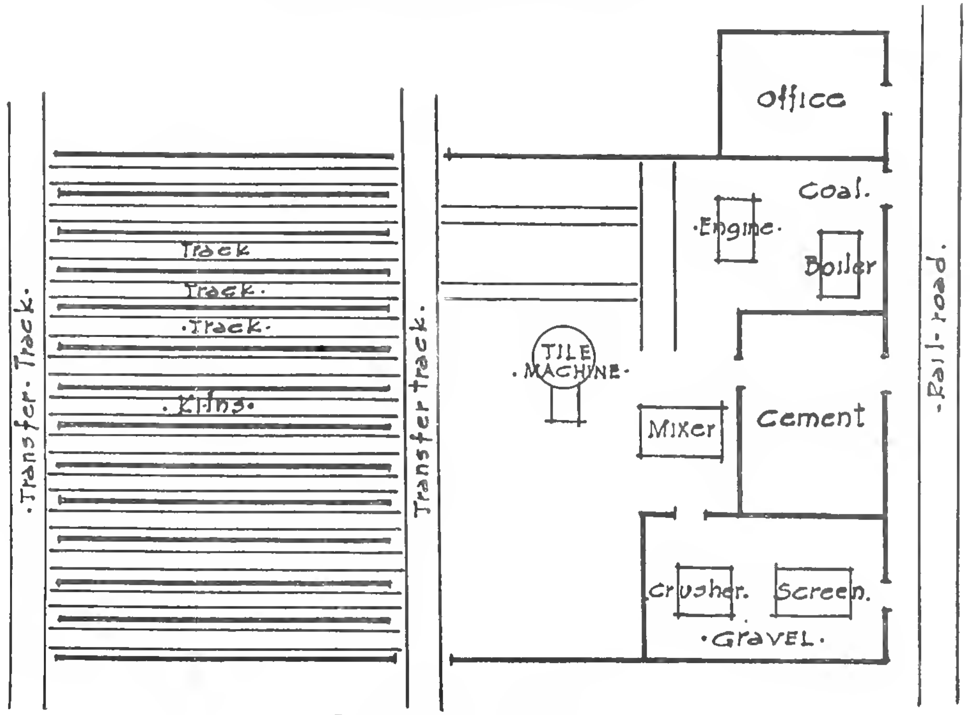
PLANT WITH DELIVERY BY BELT CONVEYORS.



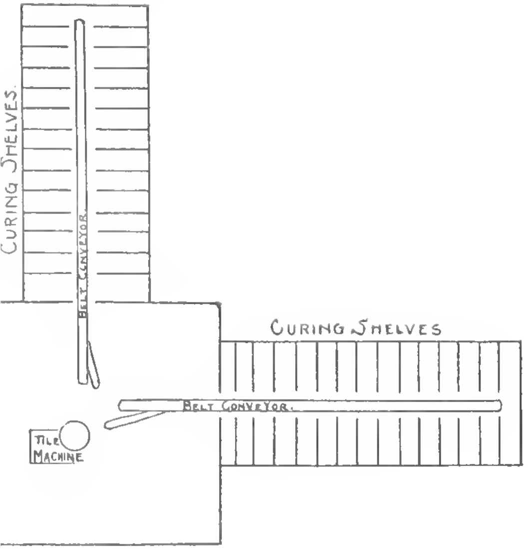
PLANT AT MORRISON, ILL.



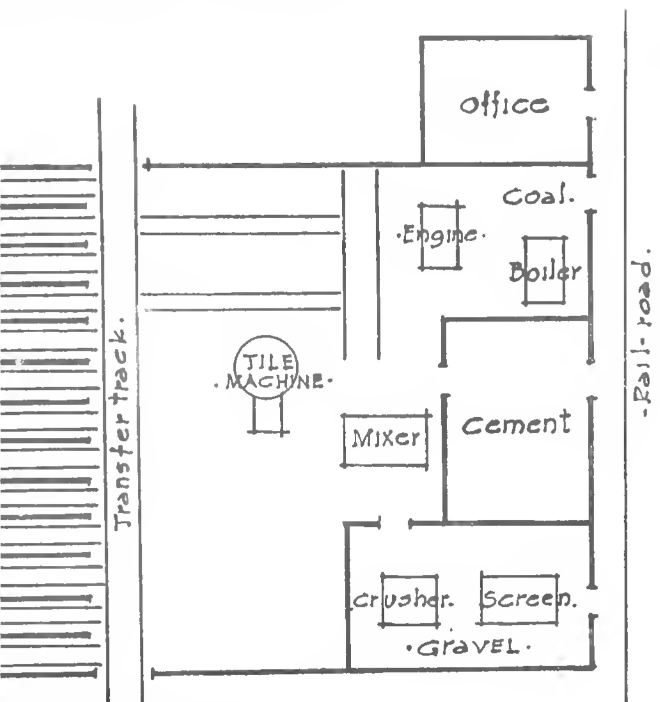
PLAN OF CONCRETE PRODUCTS PLANT OF THE PENNSYLVANIA COAL AND SUPPLY COMPANY, MILWAUKEE, WIS.



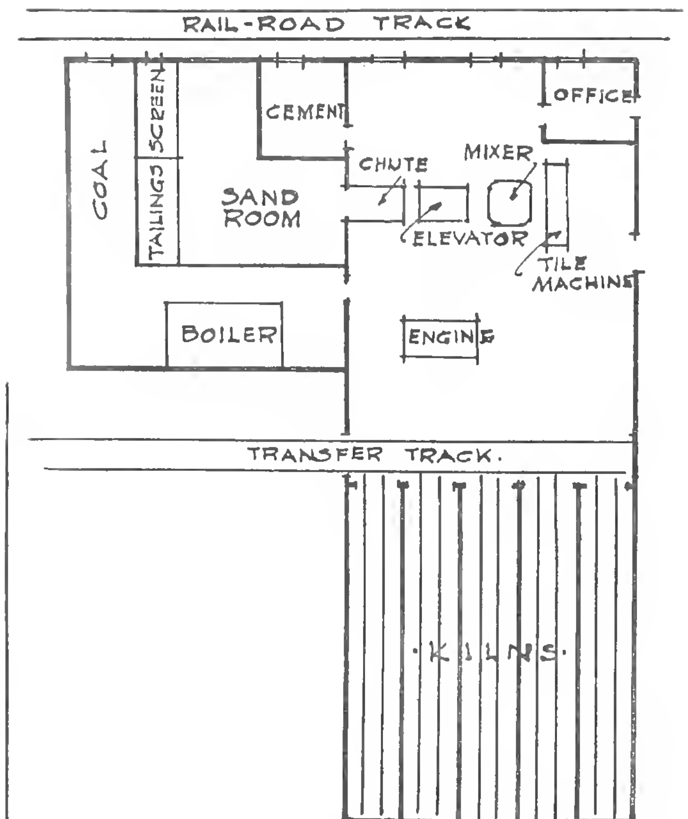
PLANT AT WINAMAC, IND.



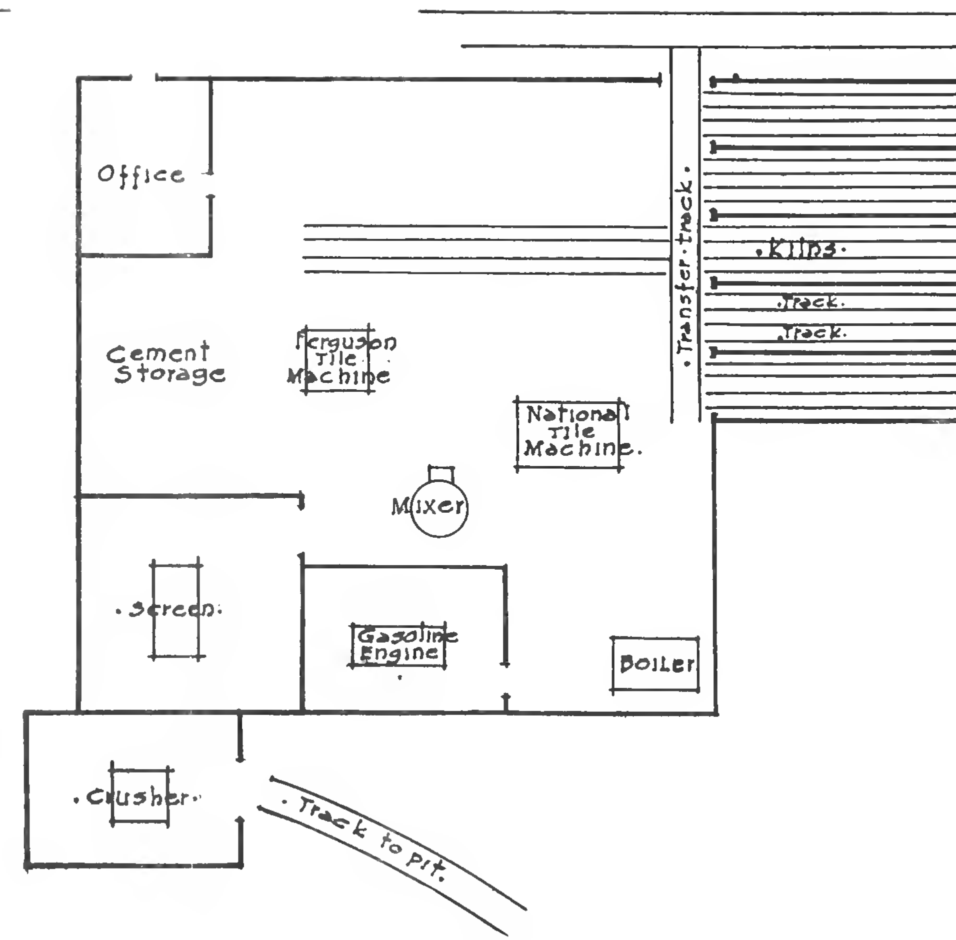
WITH DELIVERY BY BELT CONVEYORS.



PLANT AT WINAMAC, IND.



PLANT AT MORRISON, ILL.



PLANT AT EATON, OHIO.

ship to long distances, and this would eat up in freight charges what was saved in cost of manufacture.

Side Lines. The question often arises whether the manufacture of pipe and tile should be made a specialty and engaged in to the exclusion of every other line of cement product, or whether it should be carried along with other lines. This is a question which cannot be determined in advance for every manufacturer, but will be governed largely by local conditions. If a manufacturer can see that there are possibilities in his locality for developing a good sized business along the one line, he would probably do well to devote his entire time and energies to it. On the other hand, if he cannot keep his plant steadily occupied to manufacture pipe and tile and find a ready market for his product, he had better add some other line in order to keep his organization together and keep a steady output of some kind from his plant, thus reducing the overhead costs.

In the manufacture of this class of cement products, it is very essential that the workmen who become proficient should be retained steadily. This can only be done by giving them continuous work. Machines of all kinds will also deteriorate rapidly if the plant is closed up for any considerable length of time, thus not only reducing the income to zero, but absolutely increasing the plant charge.

The manufacture of blocks and other accessories for the construction of buildings can very well be worked along with the manufacture of pipe and tile, thus keeping the plant occupied through most of the working days of the year. There are almost no localities where at least a modest product of a block machine cannot be marketed to good advantage. Burial vaults are also coming into prominence as a side line for concrete manufacturers and seem to be finding a ready sale.

The man who is manufacturing drain tile exclusively would perhaps do well to develop side lines which would appeal especially to farmers and land owners, such as he is already dealing with in the marketing of his main product. The concrete fence post will before long come into

prominence as a desirable adjunct to a manufacturing plant of this kind. Fence posts of concrete are gaining in popularity year by year, their principal drawback seeming to be excessive cost. This objection is more apparent than real, however, as is proven by the long life of the concrete fence posts which were first installed; and as the practical indestructibility of these posts becomes fully recognized there will be a large demand for them. Wood posts are constantly increasing in price, and methods for the manufacture of concrete posts are being so perfected as to reduce the cost, so that even in the matter of first cost the difference is approaching the vanishing point. Such things as small watering troughs and the like can also be sold to farmers, and in some cases large tanks which are molded in sections and laid up like blocks find a moderate sale. Silo blocks ought also to appeal to a large number of farm owners.

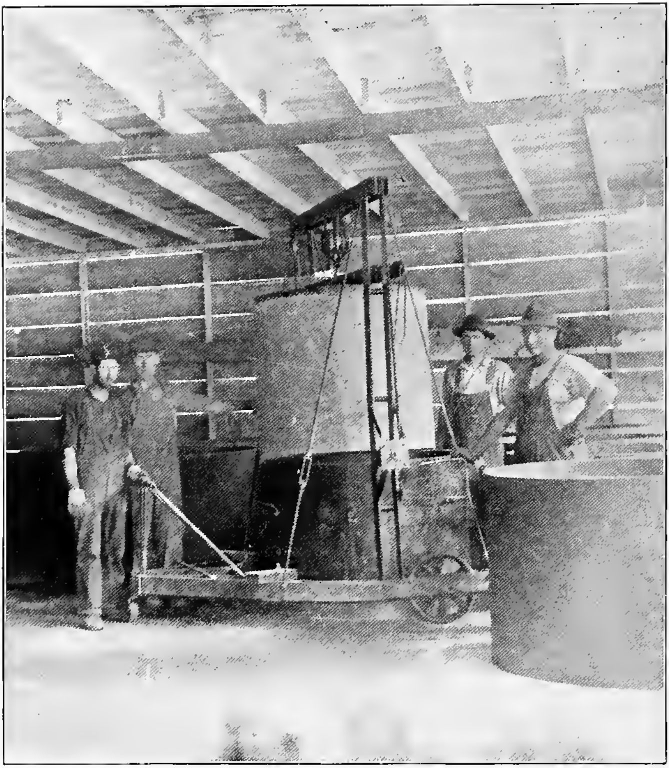
In some instances, however, the manufacture of pipe and tile itself is taken on as a side line to supplement the work of a block plant or other plant of similar nature. Occasionally, too, it is taken on to supplement a manufacturing industry of an entirely different nature, something which is seasonable and requires an additional industry to keep its power plant and part of its labor going throughout the year. In one or two instances which have come to the writer's attention, cement tile has been taken on as supplementary to canning factories, which were employed, of course, only during the season for the raising of fruits and vegetables. These are bought very largely from the farmers of the surrounding territory, thus developing an acquaintance with them which proves valuable in the marketing of the cement tile.

Most of the automatic or semi-automatic machines can be so governed as to be handled by a labor crew of various size, the output depending upon the number of men employed. The maximum efficiency not only of the machine, but of the laborers themselves, will be attained when a full crew is employed and the machine running to its full capacity.

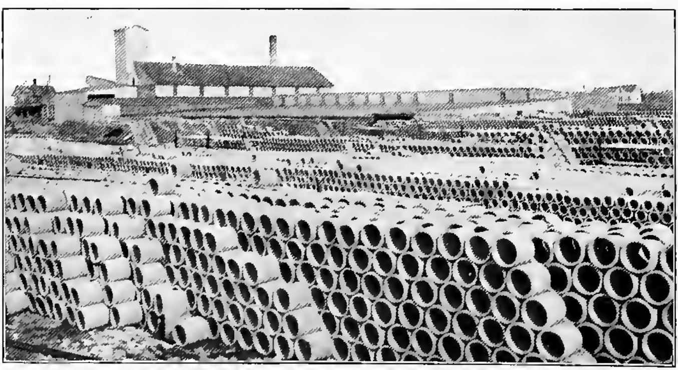
A laborer will accomplish more work when he is steadily employed at one thing than when he changes over frequently from one kind of work to another. If, therefore, the market is sufficiently active, just as many men as are required to keep up with the highest speed of the machine should be employed. If the product cannot be sold, however, and there is no side line to employ the men during dull periods, it would be better policy to run at a less capacity and with a labor force which can be made fairly permanent.

Machine mixing is usually recommended for this class of work by experts who fully understand it. Machine mixing is not only more economical, but if an efficient mixer is used, it is more reliable than hand mixing. It is usually recommended that the materials be measured by hand before going into the mixer in order to insure absolute uniformity. For this purpose a batch mixer is by some considered best. It has the disadvantage, however, of not allowing an absolutely dry mix of the materials before the water is added. The objection to a continuous proportioning mixer has been a fear of the unreliability of the proportioning apparatus, thus making a wide variation in the product, at times giving insufficient cement for strength and at times giving such an undue amount of cement as to run up the cost.

Considerable attention has been given, however, to the manufacture of proportioning mixers within recent times and some manufacturers of cement products state that they are getting excellent results with them. One or two instances have come to the attention of the writer where manufacturrs have combined batch and continuous mixers in such a way as to get the benefit of both. The materials are mixed dry in the batch mixer and then discharged into the hopper to the continuous mixer, where the water is added and the concrete delivered to the boot of the machine in a steady flow. Manufacturers of mixing machines are also developing this idea commercially and it is probable that a combined machine of this kind will at some time become a standard for parties manufacturing concrete products.



MANUFACTURING LARGE PIPE.



Car System Most Satisfactory. The car system for handling the smaller sizes of tile is the most satisfactory and economical, and is rapidly coming into general use. The number of cars required is naturally dependent upon the production and the length of time allowed for curing. With the time now usually given to curing, 100 cars is the average number used for one machine. The standard car has a 2-foot gauge and a platform 40 inches wide and 8 feet long. These cars are equipped with three decks, though four decks are sometimes used when the capacity of the curing chambers is limited. The disadvantage of the four deck car is that the tile on the top deck receives too much shaking or jarring, which increases the breakage materially. The upper decks are supported on a frame and hinged so as to be swung into a vertical position at one side of the car while the deck immediately below is being filled. The decks should be strong enough to hold the weight of all the tile which can be placed upon them without any appreciable deflection and should be constructed so as to give an even surface on which to set the tile. They are usually made with a small angle iron frame and a wooden deck of 1-inch lumber.

Cars without springs are much used and give good satisfaction provided the track is well laid and the rails are kept clean and free from sand, mortar and the like. However, springs may be used to take up the jolting of the car, but should be strong enough to allow the men removing the jackets to step on the cars without jarring down the tile.

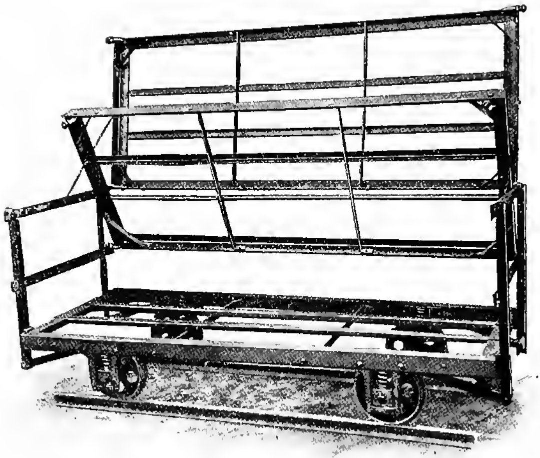
Car System of Handling. The advantages of handling tile by the car system were pointed out by Mr. Charles E. Sims in a paper before the 1911 convention of the Inter-State Tile Manufacturers Association. According to Mr. Sims, the car system of handling cement tile in the factory admits of the highest possible rate of production with the least labor. It is expensive to install but gives a plant so equipped every advantage. Continuing he stated:

The car system can be installed for about as follows:

100—cars, 36 or 40 inches wide by 8 feet long, with angle iron corner posts and two decks, @ $20.00	$2,000.00
Freight and drayage on cars, 100 mi. @ 60 cts. cwt.	330.00
Labor assembling cars, shipped knocked down	40.00
Two transfer cars @ $25.00	50.00
Freight and drayage	7.48
1,114 feet of track indoors, 12-lb. rails, for rails, splices and bolts, @ 18 cts. per ft. of track	200.52
Freight and drayage	20.00
640 ties, 4 in.x3 ft.—6 in. @ 7 cts	44.80
Labor laying and grading @ $2.00 per 100 ft. track	22.20
One switch, installed	40.00
600 feet of track in yard @ 18 cts. per ft	128.00
300 ties, 4 in.x3 ft.— in. @ 7 cts	21.00
Labor laying and grading @ $2.00 per 100 ft	12.00
Freight and drayage	14.00
Superintendence	20.00
Total	$2,950.00

Allowing 8 per cent per annum for maintenance and 6 per cent for interest on the investment we have an annual charge of $413.00 against the car system. If we are to compare it with the rack system this charge shows to the disadvantage of the car system. Although the car system requires a larger building, this fact does not operate to further disadvantage because the expense thus involved is offset almost exactly by the cost of the planks, partitions, etc., for the rack method.

Labor—Considering the labor from the time the tile are formed until they are piled in the yard the car system requires the following number of men: 4, 5 or 6-inch—two stripers, one man to push the filled cars into the curing room and bring up empties, two men to unload cars in the yard; total, 5 men. 7 and and 8-inch tile—Above mentioned five men and one additional to assist



ONE TYPE OF THREE-DECK CAR.

with cars and to relieve strippers, six men. 10 and 12-inch tile—Above mentioned six men and one additional in yard; total, 7 men.

Rate of Production—A ten-hour run under these conditions should not be attempted on sizes larger than 6-inch, for the number of cars here considered is not sufficient unless a small size is run one-half the day and a large size the other half. And, in fact, it would be impracticable to require any crew of men to work on the sizes above 6-inch, possibly I might say 8-inch, for more than five hours, if the highest rate of production is to be obtained. Under these conditions the following runs have been attained as an average for a season:

4,600—4-inch in 10 hours	920
4,500—5-inch in 10 hours	900
4,300—6-inch in 10 hours	860
4,000—8-inch in 10 hours	666
3,700—8-inch in 10 hours	616
1,700—10-inch in 5 hours	243
1,400—12-inch in 5 hours	200

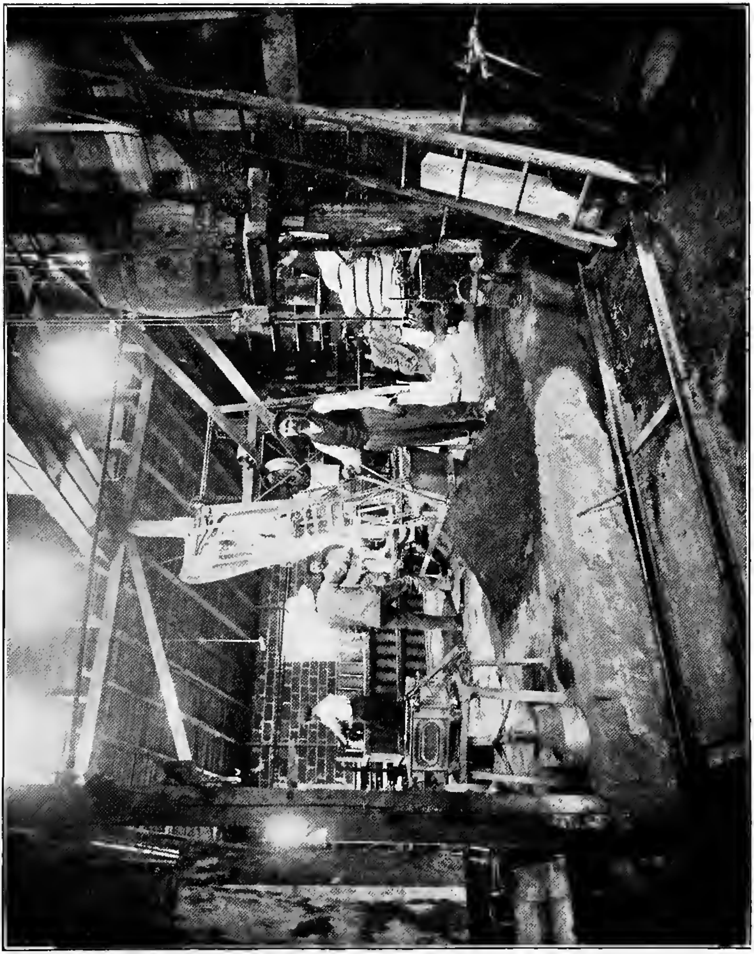
The car system offers a means of accurately counting the tile produced. The man who pushes in the cars counts the number of tile on each car and enters it on a card provided him. The count is taken when the car is on the transfer just before it is pushed into the curing room. The record is easily kept if a card 3½x7 in. is ruled off lengthwise into four columns. Head the first column "Number of Tile," and the fourth column "Track Number." After counting the tile enter the number on the car in column one, and the track number on which it is run into the curing room in column two. Each car can thus be kept on record. At the end of the day the total number of tile manufactured can be footed up exactly and recorded on the office books.

Another advantage of the car system is that the broken tile can be taken off by the man who runs in the cars and the material while fresh returned to the machine.

By recording the position of each car in the curing room it is possible for instructions to be written out each night showing to the yard man just what cars are to be unloaded the next day. With this system there is no danger of running out the tile too green.

Aside from the advantages named we have another of a different type, but one worthy of your attention. It is impossible for a crew of men to work with as good spirit and to accomplish as much in the low ceiling, poorly lighted and poorly ventilated curing rooms, where the rack system is in use, as the same men can do with the car system. In this case the machine is located where the light and ventilation are the best in an open, uncrowded space, and all the heavy work is done there. There is no tiresome walking, no confusion, and all the work is within the superintendent's sight at once. Certainly the greatest efficiency can be attained under such conditions.

The tile once on the car remains untouched until the car is run out into the yard and there it is unloaded. The rack system requires an extra handling of the tile, for it is necessary to take them off the racks and load them



INTERIOR OF A WELL-EQUIPPED TILE PLANT.

onto trucks to be wheeled out to the yard pile. Not only does the car system save this extra handling but it saves the breakage which goes with it.

Capacity of Cars. The capacity of a standard 3-deck car for the different size tile, is about as follows:

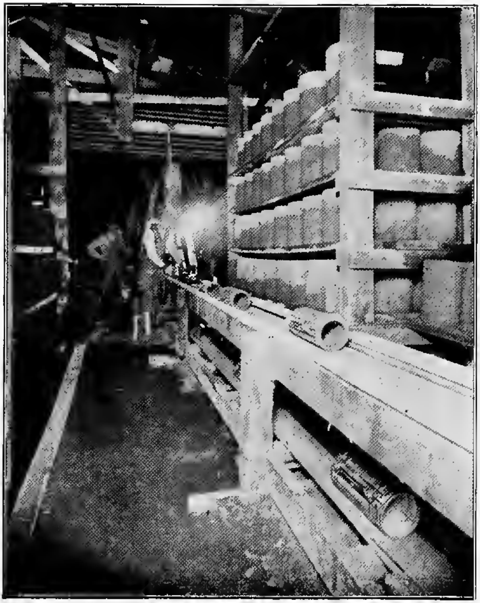
4-inch	344	8-inch	94
5-inch	244	10-inch	54
6-inch	172	12-inch	49
7-inch	112		

Belt Conveyors. A few plants have been known to use belt conveyors for carrying away the tile. In the plant illustrated, two of these conveyors are installed, running in two directions from the tile machine, as shown in the diagram.

The curing shelves are placed in two wings to the main building. One of the belt conveyors runs back to the end of each one of these wings, occupying the larger part of a central alley, with sufficient room on each side for a man to walk through conveniently. These conveyors are very simple affairs, the two outfits costing not over $150. The belt itself is a 12-inch canvas belt running over wooden rollers of about 4 inches in diameter, placed 4 feet apart. The belt runs between guides. These guides are made of dressed lumber and must be made fairly smooth, without any projecting edges or corners, in order that the molds, as they pass along, may not be caught and the tile which they carry be destroyed.

The jackets containing the tile are placed on the upper belt from the machine and are carried along until taken off by men stationed along the belt in the alleys. The empty jackets are then placed on the belt down below and returned to the main workroom, where a shunt is provided for them.

The only objection which has been found to the conveyor is that the wave motion of the belt passing over the rollers has been found to occasionally damage a tile. In this particular case, this objection has been obviated by placing a strip of steel on the rollers under the belt. If made without sharp projections, this strip of steel

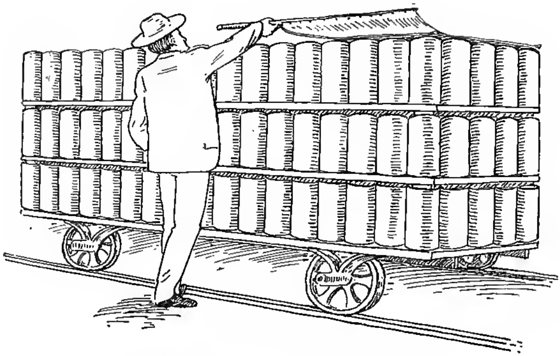


CARRYING AWAY TILE BY BELT CONVEYOR.

will not materially increase the wear on the belt and will do away entirely with breakage from the cause mentioned. Of course, a troughed belt conveyor could be installed which would do away with the up-and-down motion of the belt and would also avoid any possibility of the jackets striking the guides and shattering tile. Such a conveyor would, however, cost much more.

To Remove the "Burr" From Tile. Some tile manufactures are annoyed by the rough edge or "burr" which is sometimes left on the end of the tile by a power machine, and have taken steps to do away with it, believing that while not affecting the serviceability of the tile, it detracts from its neat appearance when the prospective customer is being shown through the yard.

One method for removing this burr is as follows: Provide a sort of "flag" by tacking to a stick about 5 feet long a piece of burlap or other heavy cloth, the length



REMOVING "BURR" FROM TILE.

of which is slightly greater than the width of the cars on which the tile is removed from the machine. After a deck is filled, this flag is then passed once or twice over the tops of the tile.

A beginner will probably have to have a little experience before he can gauge this process, giving the flag sufficient drag on the top of the tile to remove the burr, and not enough to break down the tile itself.

Double-Strength Tile for Culverts. These can be made by using the shell of one size and the core of the next smaller size. Thus, by using a 16-inch core in the outer shell for an 18-inch tile, a tile of double thickness can be secured, suitable for road culverts where the fill is not sufficient to give the proper protection to an ordinary pipe.

Thickness of Shell. The following are the standard thicknesses of shell in general use:

Diameter.	Thickness.	Diameter.	Thickness
4-inch	½-inch	10-inch	⅞-inch
5	9/16	12	1
6	⅝	14	1¼
		16	1⅜
7	11/16	18	1½
8	¾	24	2

The general rule is that the wall shell be one-twelfth the diameter of the tile, but in no case less than ½ inch.

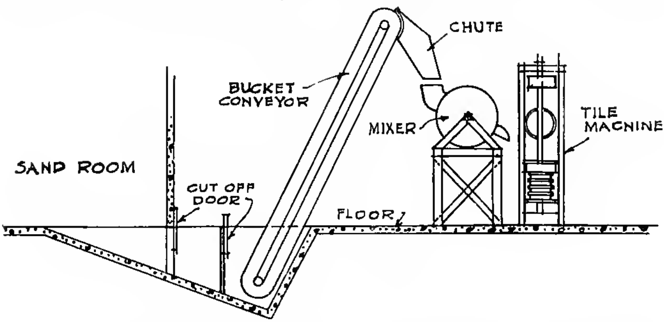
Prevent Tile From Freezing to Ground. If the sales are large during the winter months, it is desirable to place the stock piles on a layer of straw or other material, as it is very often that the lower row of tile freezes to the ground, which prevents the wagon from getting close to the pile, and they cannot be loaded without much extra labor, if something of this kind is not done.

Distance Between Yard Tracks. The arrangement of the stock piles should be such that the wagons may be loaded with any size and leave the yard by crossing the fewest number of tracks. This is accomplished best by piling the tile in long rows parallel to the track. The distance between tracks may be anything desired. Some prefer not to have a greater distance than 20 feet between the center line of the track and the center of the roadway. Others have found a distance of 50 to 75 feet to be a convenient width. In the latter case, to avoid carrying the tile long distances when unloading the cars, they are rolled down a chute about 14 inches wide with 4-inch sides and 20 to 24 feet long, one end of which is placed on the edge of the second deck of the car. The tile can be rolled 30 to 35 feet and this method proves very satisfactory for all the smaller tile larger than 5 inches.

Keeping Record of Tile. In order that no tile may be removed from the curing chambers too soon it is well to have the man handling the cars of small tile to the curing chambers keep a record of the number of tile of each size on each car and the number of cars placed in each chamber. The man removing the jackets from the large tile can keep a record of the number of each size placed in the different chambers, these records to be handed in at the office twice a day. By this practice a memorandum showing the number of cars and the number and size of large tile in the different rooms which are to be put in the yard that day, may be given to the yardman every day. From these records can be compiled the day's output and the stock on hand. Some allowance must be made for breakage, otherwise the number of tile in the

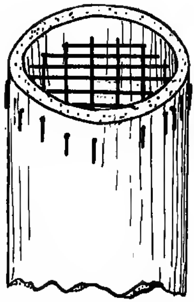
yard will not agree with the number of tile made by the machines.

Sand Rapidly Measured and Delivered. In the sectional view here shown, the sand room has on one side a hopper floor, connecting with a chute to the main workroom by a cutoff door. Another cutoff door serves to form a small bin in the workroom. A reference to the cut will serve to make this arrangement perfectly plain. The cutoff door in the wall between the sand room and the main workroom may be called Door No. 1, and the



other Door No. 2. Door No. 2 is first closed and the Door No. 1 opened, allowing the space between them to be filled with sand. Door No. 1 is then closed and the requisite amount of cement added to the sand. Door No. 2 is then opened, allowing the cement and sand to flow down against the bucket conveyor, which carries the materials up and deposits them in the mixer hopper. After mixing, the concrete is delivered on to a convenient table, from which the tile machine operator takes it into the machine as needed.

Screen for Inlet Pipe. An inlet joint, or other pipe, which it is desired to screen, can be screened in the following manner: About an hour after the tile is made and before it has fully set, push pieces of wire through the walls in two directions at right angles to each other, as shown in the illustration. The size of wire and size of mesh can be regulated according to the size of the pipe and service desired. A 1-inch mesh will answer most



SCREEN FOR INLET PIPE.

purposes. Leave the wires this way until the tile has become thoroughly cured, then turn the ends down with a hammer to hold them in place.

Making Y's and T's. Y's and T's in cement pipe and tile can be quite easily made without the use of any special molds. The best time to do this is just before the concrete begins to get hard and it can be cut with a knife, but after it has attained sufficient stability so that it will not fall to pieces.

In making these special forms, the best manner to proceed is to first cut off the end of one of the pipes in such a way that it will fit snugly against the other one at the desired angle. When this is done, press it against the other pipe at the point where it is decided to make the hole and mark carefully around it. Then cut out this hole with a knife and fit the other pipe into it, providing it with some kind of support both inside and outside. so that it will remain in place, and pour into the joint as much cement grout as it will take. After this is allowed to harden, the joint can be further strengthened by filling it in with cement mortar.

Sometimes it is not always practicable to make these special forms until after the pipe is out on the job and has attained its maximum hardness. This can be done with a little care exercised in cutting the holes in the sections, although a concrete pipe is not easy to cut into. The manner of making joints in this way may be described as follows:

Suppose you wish to make a T joint for joining a 10-inch sewer pipe to a 24-inch main sewer. For this purpose you should have some pieces of 10-inch pipe made not over 12 inches in length, that is, 12 inches above the bell. Select a good, sound, well tamped 24-inch pipe from your stock that is two or three weeks old. It will cut best at this time, but can be cut at any time and at any age. Bed the large pipe in sand, so as to keep it from rolling, and give it a soft bed to lie in. Take the small section of pipe to be joined to it, cut it so that the end of it will fit the outer shell of the large pipe. Set the small pipe on the large pipe and with a pencil or sharp instrument, describe the circular line on the outside of the large pipe around the end of the small pipe, where you wish to cut the hole. Wet the large pipe thoroughly, then, with hammer and chisel, cut a line around the hole you wish to make about half an inch inside of the line that you have drawn. Keep on cutting carefully until you get about half way through the pipe all the way around; then cut the balance of the way through in three or four places about half way around the hole, and tap the piece gently from the inside, and the piece will come out easily, just where it has been cut.

Now trim or rim out this hole with a chisel until it fits the pipe that you wish to insert. After this hole has been trimmed so the small section will slide in easily, wet the end of the small pipe to be joined and the large pipe where it has been cut thoroughly, and go over it with a solution of neat cement of about the consistency of thick cream, a small brush being used. Then insert the small section of pipe in the opening where it is to be joined to the large pipe and brace from the inside so as to hold it in position, being careful that the end of the small section does not project beyond the inside of the shell of the larger pipe. After this has been firmly braced in position, mix up a cement mortar so it will handle easily with a trowel, about one part of cement and one part of fine sand, and fill around the junction. This junction at the angle where the two outside surfaces meet can be built

up and strengthened in this manner with cement mortar to give any required strength, and it really becomes the strongest part of the pipe.

This joint is then wiped with a solution of neat cement, the same as was used at the start, the same as a plumber wipes a lead joint. In this manner a very strong and durable, as well as neat-looking, pipe is produced.

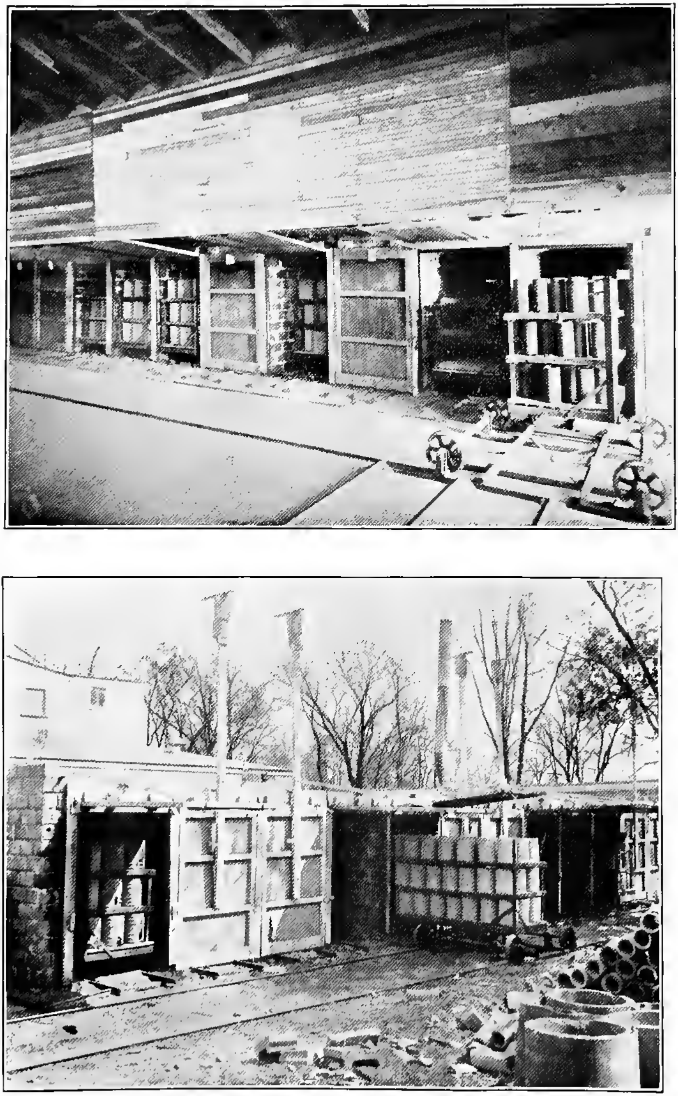
The next day the braces from the inside can be removed and the inside plastered, the same as the outside has been, with a rich cement mortar, and the inside made perfectly smooth by the use of the solution of neat cement and water applied with a small brush.

Weight of Tile. The following weights, taken from a manufacturers' catalogue, are given only as an average; the weight of concrete tile depends largely on the aggregate used in the manufacture. Tile 4 to 16 inches, inclusive, are 12¼ inches long; 18 to 24 inches, 2 feet long.

Size.	Weight.	—Average Car Load—	
4-inch	6 lbs. per foot	6,500 pieces	406 rods
5 "	8 " " "	5,000 "	312 "
6 "	11 " " "	4,000 "	250 "
7 "	14 " " "	3,000 "	187 "
8 "	18 " " "	2,400 "	150 "
10 "	25 " " "	1,600 "	100 "
12 "	35 " " "	1,000 "	62 "
14 "	48 " " "	800 "	50 "
15 "	55 " " "	600 "	37 "
16 "	65 " " "	500 "	31 "
18 "	75 " " "	200 "	24 "
20 "	87 " " "	166 "	20 "
22 "	100 " " "	160 "	19 "
24 "	115 " " "	150 "	18 "

Timing The Output. Our manufacturer keeps a watch hanging on his tile machine, so that the operator can time his output. When running on 5 and 6-inch sizes he is expected to keep the output up to eight tile per minute.

Effective Method of Advertising. An Indiana manufacturer, whose plant is near the railroad, has erected a pyramid of tile in his storage yard for the purpose of calling attention to his product.



TWO VIEWS OF CURING CHAMBERS.

CHAPTER IX.

CURING.

Importance of Curing. If there is any one stage in the manufacture of pipe and tile which is more important than another, it is the curing. This was not recognized in the earlier stages of the industry, and the result was that much improperly cured tile was placed on the market. The chief fault seemed to be that it was not given sufficient moisture for a long enough period, or that it was allowed to dry out between the time it was taken from the machine and the time it was given the first moisture in the curing room. Sometimes it was allowed to stand in the sun and wind of a hot summer day; and again, in winter it was allowed to come too close to the freezing point.

Proper curing is, however, now generally recognized as of prime importance, and it is not customary to find at the present time any products of this kind which are not at least passably well cured.

Two Methods of Curing. There are two general methods in use for the curing of all classes of concrete products. One of these is the method of subjecting the product to the action of low pressure steam in a curing chamber, and the other the so-called natural method, by which the product is saturated with water at stated intervals. While both of these are still in use in the manufacture of pipe and tile, most manufacturers are gradually taking up the method of steam curing. There are two reasons for this: One of them is that this class of product has to be made rapidly and in large quantities in order to make it productive, thus overburdening the manufacturing space if the slower natural method is relied upon; another reason is that this class of product, having compar-

atively thin walls and being subjected to a considerable strain, must necessarily attain the full strength of which it is capable. This can be best secured under conditions which can be maintained practically uniform and under control of the operator. Pipe and tile will cure much more rapidly by steam than by the natural method, and can therefore be passed through the plant and into the storage yard in much less time.

Natural Curing. The original method employed in natural curing, and which is still in use in some plants, is what is known as the Rack and Shelf method, these racks and shelves being made of lumber of sufficient strength and usually placed in one large room protected from the sun and from currents of air. To these racks the sections of tile are carried as they are taken from the machine and placed on the shelves and are later sprinkled with a hose as they attain sufficient set not to fall into pieces under the water.

A later development of this process has been to divide the curing room into smaller chambers of from 4 to 8 feet wide, the tile being placed on movable shelves resting on cleats at the sides of the room. Shelves of this kind can be placed one above the other, allowing just sufficient space for the placing of a length of tile, and afford maxiimum efficiency so far as utilizing all space is concerned.

The advantage of a separate chamber of this kind lies in the fact that it protects the tile to a greater extent from drafts of air, thus tending to hold the moisture which it contains. The objection to the natural system of tile curing is, however, in addition to the fact that it takes a longer time, that most manufacturers will not take sufficient precaution against the tile drying out before they are sufficiently hard to be sprinkled, thus giving them a minimum amount of moisture just at the time when they are most in need of it.

Under this system the tile, as before stated, should be sprinkled just as soon as they will stand up under the water and should be sprinkled about three times a day for at least six days, though the sprinkling will depend

to a considerable extent upon atmospheric conditions. After this the tile may be stored in the yard, where it should remain at least 24 days before being shipped out.

Steam Curing. Steam curing can be effected in a period of 48 hours. The steaming chamber should have a temperature of not less than 70° Fahr., or more than 120°, and the tile should be placed therein within one hour after being made. The ordinary method has been to use exhaust steam for curing. In a number of plants, however, gasoline or electricity are used as motive power and a boiler is provided solely for the curing of the product. Where the steam goes direct from the boiler into the curing room it should be at a pressure of not more than 5 pounds. It is absolutely necessary that the steam as it goes into the curing room shall be moist, as dry steam will do more harm than good and steam at a pressure of more than 5 pounds may not carry sufficient moisture for the purpose. The best method to insure moisture at all times is therefore to have the steam pipe embedded in the floor of the curing chamber with its outlet through a trough or chamber of water. Where such an arrangement as this is used, a boiler pressure up to 80 pounds can be safely utilized. An additional day's time should be given to the steaming in freezing weather, and in all cases the tile should be left in the yard 14 days before being sent out. Some manufacturers insist that it shall be sprinkled for the first two or three days of that time.

Size of Curing Rooms. Curnig rooms should preferably be about 4 feet wide, to allow one track; 6 feet high to allow workmen to enter conveniently, and long enough to accommodate either three or four cars. Many plants have curing rooms larger than this, some of them carrying two and three tracks; but the smaller size is coming to be recognized as preferable because of the fact that they allow less circulation of air when they are open, and can be closed to the outer air sooner than those which have to be left open for a larger amount of tile.

Materials of Construction. Almost any construction

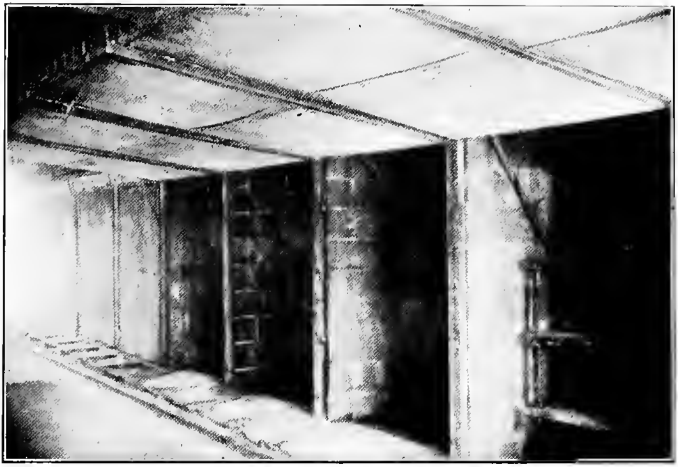
which is reasonably steam tight can be employed. Some of the more substantially constructed plants have curing rooms with walls of concrete blocks and rough arched roofs of reinforced concrete.

Curing Room of Building Paper. The simplest form of curing chamber is that made with sides and doors of building paper. A false ceiling can also be made of this material in case the building is too high and otherwise undesirable for running the partitions to the top. A good grade of paper should be used, of a kind well impregnated with tar, so that it will not be affected by moisture. It can be nailed to a framework of 2x4 studding.

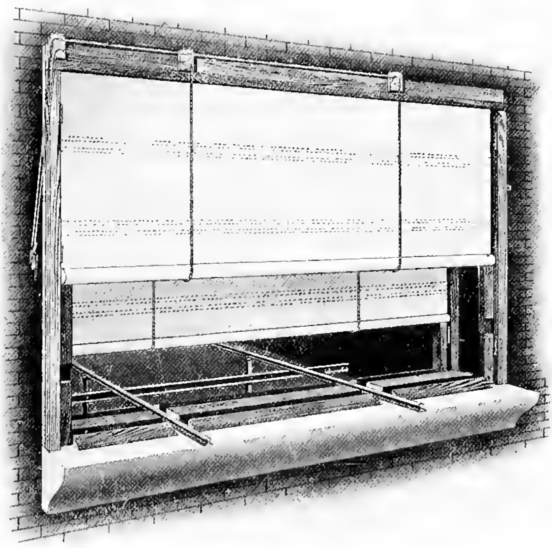
Unusual Method of Steaming. An unusual method of supplying saturated steam to curing rooms is employed in a Milwaukee Sewer plant. Attached to the kilns are brick furnaces, fired with coal. Above the fire, through the walls of the furnace and into the curing room passes an iron pipe, into the opening of which water is allowed to drip. This is converted into steam as it passes over the hot pipe and the steam is disseminated throughout the curing rooms. By this method it is thought that a supply of steam with sufficient moisture at all times to give the proper crystallization to the concrete is assured.

Upward-Swinging Doors. Some space can often be saved and much inconvenience avoided by having the doors of curing chambers hinged at the top and swinging upward. They can be hooked to rafters and be entirely out of the way while the chamber is being filled. Rolling canvas doors are also on the market, having bearings on the ends of the rollers, working in slots to hold them in position. For greater tightness these are sometimes made double.

Number of Tile in a Curing Room. A curing room 32 feet long, 7 feet wide and 10 feet high, and fitted with the rack system, allowing for (7) courses of tile in height, will hold approximately 4,000 tile of 5 or 6-inch size. One room will thus take the output of a machine for one day.

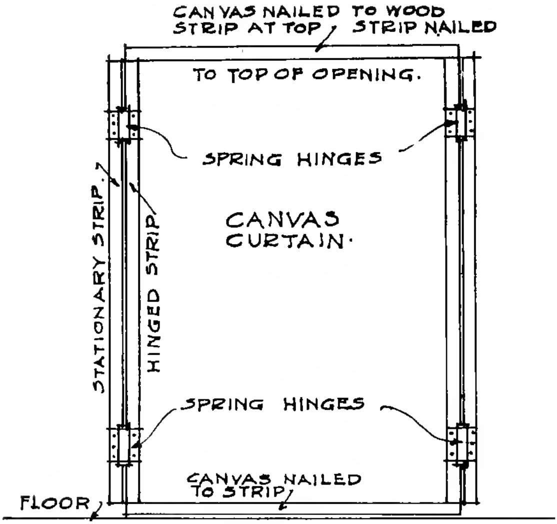


UPWARD SWINGING DOORS.

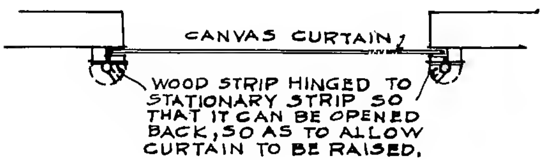


ROLLING CURTAINS.

To Make Canvas Curtains Steam-tight. In many plants these curtains are allowed to hang free, thus permitting much steam to escape. This can be obviated by having stationary strips nailed on to the walls at the sides of the curtains and other strips hinged to these with screen-



·ELEVATION·



·PLAN·

door hinges. When the curing room is filled, the curtain is lowered and these movable hinged strips are turned down over the edges of the curtain, the spring hinges holding them tightly in place and making a practically steam-tight joint.

In addition to this precaution, the canvas curtains may be painted so that no steam can penetrate through them.

Rotten Period. It has been noted by some manufacturers of cement tile that the tile has what they have termed "a rotten period," during which time it is much more susceptible of breakage than earlier or later. This period occurs from about the eighth to the twentieth day, so that tile only three or four days old is found very often to be much stronger than it is during this period. After this time it again begins to gain strength, increasing in resisting powers until its ultimate strength is reached. The explanation of this phenomenon is supposed to be as follows: The tile is usually kept moist during the first seven days, during which time the process of crystallization goes on quite rapidly, giving the tile increased strength from day to day. After the seven days, tile is taken into the yard where it dries out very rapidly. Crystallization is therefore retarded and the tile loses in strength. After a week or ten days it begins to draw moisture from the atmosphere and the process of crystallization again goes forward more rapidly.

CHAPTER X.

The Matter of Costs.

Method of Cost Keeping. The method here shown is suggested by Mr. J. H. Libberton of the Universal Portland Cement Company. By this method space is saved and the bookkeeping reduced to a minimum. It will be necessary to use two styles of cards, Figs. 1 and 2, one for the daily record about 3x5 inches in size, and the other for cost and stock, preferably about 5x8 inches. The Daily Report Card is to be made out by the foreman and each size of tile should be filled in, showing the time re-

DAILY REPORT. Date *6/21/09*

Size.	Number.	Sacks Cement.	Hours.	Hours Labor.	Remarks.
8"	*2,400*	*92*	*10*	*100*	*New packer heod.*

Fig. 1.

quired as well as the cement used for each size. The cards are perforated so that they can be hung on a nail in the factory. This record is turned in at the close of each day and the different items transferred to the large cards under the various sizes, after which they are filed in a separate drawer, marked "Day" or "Daily Record." The tile per sack is then determined for each size by

8" TILE

Day.	No. Tile.	Sacks Cement.	Tile Per Sk.	Mix.	Am't Sand.	Cdst Cem.	Cost Sand.	Cost Labor.	Cost Fuel,&c.	Total.	STOCK. Forw'd 5,000.	STOCK. Sales.	STOCK. On Hand.
6/21/09	2,400	92	26.1	1:4	368	$34.50	$13.62	$20.00	$18.30	$86.42	7,400	1,000	6,400

Fig. 2.

dividing the number of tile made by the sacks of cement used and multiplying the sacks of cement used by the proportion gives the cubic feet of sand.

After the amount of material has been determined, the cost should be added on the large cards. From it will be possible to determine immediately the cost of sand. The cost of cement, being variable, must be figured for each entry. The labor is calculated by multiplying the hours by the rate per hour.

The next column will include the interest, power, depreciation, etc., and must be proportioned to the size of tile. For instance, if the daily cost for these items was $9.00 and the average number of tile made per day of a certain size was 3,000, the charge per 1,000 would be $3.00 If, however, the plant was working on tile of which the plant produced only 1,500 per day, the added cost would be double the other or $6.00 per 1,000.

The several items of sand, cement, etc., when added together give the total cost for the total number of tile of one size made on a certain day. The cost per 1,000 can be obtained by dividing the total cost by the number of thousand tile made.

The next division on the large card is intended to be a perpetual inventory of stock on hand. At the top under "Forward" should be placed the total from the last card filed. To that number is added the day's production. After subtracting the sales for the day, the last column should indicate the stock on hand.

Good Profit on 4-inch Tile. From the records of an Ohio plant, we take an average day's run of 4-inch tile, which is 188 rods, the cost of which is as follows:

9½ barrels of cement @ $1.20	$11.40
6 1-3 yds. sand @ 60c	3.80
Labor	12.75
Overhead expense, repairs, fuel, etc	4.00
	$31.95

This size of tile is sold at 30 cents per rod, so that the proceeds for the day's output of 188 rods would be $56.40, or $24.45 above the actual cost of production.

Indiana Man's Experience. A manufacturer of cement tile in Indiana, using a power machine, furnishes the following data or runs on 5 and 6-inch tile, the proportions varying from 1:4½ to 1:5. A 12-day run on 5-inch tile made 36,860 tile, using 574 sacks of cement and labor of—

1 pit man, per day	$ 1.50
1 mixer, per day	1.75
1 boot man, per day	1.75
1 machinist, per day	1.75
1 stripper, per day	1.75
2 yard men @ $1.50 per day	3.00
3 offbearers @ $1.00 per day	3.00
12 gallons gasoline	1.26
	$15.76

Labor and gasoline 12 days @ $15.76 per day	$189.12
574 sacks of cement @ $1.25 per bbl	179.37
90 yards of gravel @ 40c per yard	36.00
Total	$404.49

Making an allowance of 3 per cent for breakage, this makes a cost of $11.31 per 1,000.

On 6-inch tile the figures furnished by the company are as follows: In 12 days 33,148 tile were made, using 664 sacks of cement and labor of—

1 pit man @ $1.50 per day	$ 1.50
1 mixer man @ $1.75 per day	1.75
1 boot man @ $1.75 per day	1.75
1 stripper @ $1.75 per day	1.75
2 yard men @ $1.50 per day	3.00
3 offbearers @ $1.00 per day	3.00
Total labor for one day	$14.50

Labor cost for twelve days' run @ $14.50	$174.00
664 sacks cement @ $1.25 per bbl	207.50
144 gallons gasoline @ 10½c	15.12
100 yards sand and gravel @ 40c	40.00
Total	436.62

Again allowing 3 per cent for breakage, the figures show this size to cost $13.23 per 1,000.

TABLE FOR ASCERTAINING COST.

The following table for ascertaining the cost of producing tile at different rates of wages and prices of materials has been prepared by the XL-All Manufacturing Company of Chicago. In order to figure the cost for your plant, use the figures which prevail in your locality and disregard the others. The figures under "Selling Price" are put in for purposes of estimating profit. The manufacturer can substitute the selling price in his own particular locality.

Size of Tile.	No. Made per Day.	*Labor* Cost per M—7 Men 10 Hours Per Day, at Rate per Day. as given at top of each Column.			No. of Tile per Cubic Yard of Concrete.	No. of yards of Sand per M Tile.	No. of bbls. of Cement per M Tile 4:1.	*Sand* Cost of Per M Tile at Price per Yard, as given in the figures at top of each Column.				*Cement* Cost of per M Tile at Price per Barrel, as given in figures at top of each Column.					Selling Price.
		$1.50	$1.75	$2.00				$0.25	$0.50	$0.75	$1.00	$1.00	$1.25	$1.50	$1.75	$2.00	
4 inch......	4000	2.63	3.07	3.50	480	2.08	3.52	.52	1.04	1.56	2.08	3.52	4.40	5.28	6.18	7.04	$22.00
5 inch......	3850	2.73	3.18	3.63	396	2.53	4.29	.63	1.26	1.89	2.53	4.29	5.38	6.42	7.50	8.58	28.00
6 inch......	3750	2.81	3.27	3.73	285	3.52	4.80	.88	1.76	2.64	3.52	4.80	6.00	7.20	8.40	9.60	38.00
7 inch......	3650	2.88	3.36	3.83	225	4.46	7.54	1.11	2.23	3.34	4.46	7.54	9.43	11.36	13.21	15.08	48.00
8 inch......	3500	3.00	3.50	4.00	181	5.52	9.32	1.38	2.76	4.14	5.52	9.32	11.65	14.20	16.35	18.64	60.00
10 inch......	3250	3.24	3.78	4.31	134	7.48	12.62	1.87	3.74	5.61	7.48	12.62	15.80	18.96	22.20	25.24	90.00
12 inch......	3000	3.51	4.09	4.66	96	10.42	17.60	2.60	5.21	7.81	10.42	17.60	22.00	26.40	30.80	35.20	115.00

Some Figures on Larger Sizes. The following table of costs has been compiled by the Quinn Wire and Iron Works, Boone, Iowa, and is based on the use of their National cement tile machines. The prices are for 1,000 feet of tile, with the following cost of labor and materials: Seven men at $2.00 per day; one foreman at $3.00 per day; cement at $1.60 per barrel; sand at $1.00 per yard; gasoline for 6-horse engine at 15c per gal.

Size	Wall	Est'm. Weight	Actual Weight	Cement: Sacks	Cement: Cost	Cement: Total	Sand: Yards	Sand: Cost	Sand: Total	Labor: Help	Labor: Foremen	Power	No. ft. Tile Per Day	TOTAL
14	1¼	110	100	125	40c	$ 50.00	14	$ 1.00	$ 14.00	$20.00	$ 4.30	$ 1.35	700	$ 89.65
15	1¼	117	120	150	40c	60.00	16⅔	1.00	16.67	20.00	4.30	1.35	700	102.32
16	1½	150	150	187	40c	74.80	21	1.00	21.00	20.00	4.30	1.35	700	121.45
18	1¾	202	200	250	40c	100.00	28	1.00	28.00	23.30	5.00	1.50	600	157.80
20	1¾	216	220	275	40c	110.00	31	1.00	31.00	28.00	6.00	1.80	500	176.80
22	2	282	280	350	40c	140.00	40	1.00	40.00	28.00	6.00	1.80	500	215.80
24	2	304	300	375	40c	150.00	42	1.00	42.00	35.00	7.50	2.25	400	236.75
26	2⅛	346	340	425	40c	170.00	48	1.00	48.00	35.00	7.50	2.25	400	262.75
28	2¼	393	400	500	40c	200.00	55	1.00	55.00	40.00	8.60	2.85	350	306.45
30	2½	472	470	588	40c	235.20	66	1.00	66.00	47.00	10.00	3.00	300	361.20
32	2½	512	525	656	40c	262.40	73	1.00	73.00	47.00	10.00	3.00	300	395.40
36	3	680	700	875	40c	350.00	97	1.00	97.00	58.00	12.00	3.80	250	520.80

Four-inch Tile at $15 per 1,000. These figures are from a plant equipped with a power drain tile machine and a continuous mixer, operated by a gasoline engine. The factory runs 10 hours a day and turns out 3,500 tile per day of the 4 to 6-inch sizes, and from 2,000 to 2,300 of sizes up from that to 12 inches. To accomplish this the following labor cost is required:

1 man hauling sand	$ 3.50
7 men at factory at $1.75	12.25
2 men and teams hauling away	7.00
	$22.75

Sand is secured from a river bed near by. It is pumped out with a centrifugal pump and banked up, costing about 10 cents per yard at the bank.

Water is brought from the city at the rate of 11 cents for 1,000 gallons, and the bill averages about $1.00 per day. Gasoline costs about 75 cents per day.

For the most part the tile is made in the proportion of 1 to 4. With an average output of, say, 3,400 per day of the 4-inch tile, 10 yards of sand will be used and 17 barrels of cement. The cost can therefore be figured out as follows:

Labor cost as above	$22.75
10 yards sand (at pit)	1.00
Water	1.00
17 barrels cement, at $1.50	25.50
Gasoline	.75
	$51.00

This works out to a cost of $15.00 per 1,000 feet.

Making 24-inch Tile in Hand Molds. These figures are from a plant in northwestern Iowa. Two molds are kept going, with two men at each mold. Each mold also requires a wheelbarrow man to deliver concrete and shovel it in. Added to these are a man in the sand bin, a man who runs the mixer and sprinkles the finished tile, and a young man who is engineer and generally handy man. There is also, as before, the man and team hauling sand. These, in a day of 8 hours, make 100 of these 24-inch tile. Each tile consumes a trifle more than one sack of cement

and 3 cubic feet of sand, and weighs approximately 300 pounds.

The cost may be worked out as follows:

1 man and team hauling sand	$ 3.50
9 men at $1.60	14.40
26 barrels cement at $1.40	36.40
12 yards of sand (cost at pit)	1.20
Fuel and incidentals	2.00
	$57.50

For 100 tile per day this would make a cost of 57½ cents.

Another Iowa Plant. A similar plant to the above was visited in another part of the state. The output as a general thing runs about as follows:

12 inches diameter, 2,000 to 2,200 per day.
10 inches diameter, 2,200 to 2,500 per day.
8 inches diameter, 2,500 to 2,800 per day.
7, 6 and 5 inches diameter, 3,000 to 3,500 per day.

On sizes up to and including 8-inch the following are required:

1 man and team hauling sand	$ 3.50
1 man screening	1.75
1 man mixing	2.00
1 man feeding the machine	1.50
1 man running the machine	2.50
4 men carrying away	8.00
2 men wheeling to yard	3.00
Half time of boy sprinkling	.50
Half time of foreman	2.50
Half time of yard man	1.00
2,000 gallons of water	.36
9 gallons of gasoline	1.04
	$28.15

With a product of 2,600 8-inch tile per day, the above items would enter into the cost to the extent of $10.83 per 1,000. For 1,000 of this size, 7 yards of sand will be required, which amounts to 70 cents at the pit, the cost

of hauling being included in the above table. Adding to this $18.00, the cost of 12 barrels of cement required, we have a total cost on 8-inch tile of $29.53 per 1,000.

When the plant is running on 10 and 12-inch tile, an extra man is required on the mixer and two extra men on the machine, as well as additional yard and teaming help, making an additional cost of $9.20. Adding this to the $28.15 above, we have $37.35. Assuming the average daily output of 10-inch tile to be 2,500, which would require 30 yards of sand and 50 barrels of cement, the cost would be as follows:

Labor, etc.	$37.35
Sand	3.00
Cement	75.00
	$115.35

This would be a cost per 1,000 feet of $46.14.

Labor Cost with Hand Molds. On this part of the work in an Iowa plant the mixing is done by hand, three men mixing their own batch and molding. Dividing their time equally among 14, 18 and 24-inch tile, they will average from 80 to 90 tile per day. The cost will run about as follows:

1 man and team hauling sand	$ 3.50
3 men at $2.00	6.00
1 man delivering to yard	1.75
Half time of foreman	2.50
Half time of yard man	1.25
Half time of water boy	.50
2,000 gallons water	.36
	$15.86

Itemized Cost on 4 to 12-inch Tile. The following figures are from an Illinois plant, and were compiled by Mr. J. H. Libberton of the Universal Portland Cement Company:

MATERIAL COST PER 1,000 TILE.

Tile Diameter, Inches.	Cement, Bags.	Sand, Cubic Yds.	COST. Cement.	Sand.	Total.
4	3.25	1.44	$ 4.87	$ 1.44	$ 6.31
5	4.55	2.01	6.82	2.01	8.83
6	595	2.64	8.90	2.64	11.54
7	7.59	3.37	11.40	3.37	14.77
8	9.60	4.27	14.40	4.27	18.67
10	13.40	5.96	20.10	5.96	26.06
12	19.40	8.63	29.10	8.63	37.73

FIXED COST PER 1,000 TILE.

Size, Inches.	Production.	Foreman.	Interest, etc.	Power.	Total.
4	2,900	$ 2.76	$ 3.02	$ 0.52	$ 6.30
5	3,000	2.66	2.92	.50	6.08
6	3,000	2.66	2.92	.50	6.08
7	2,500	3.20	3.50	.60	7.30
8	2,400	3.34	3.65	.63	7.62
10	1,800	5.45	4.86	.84	10.15
12	1,450	5.50	6.04	1.04	12.58

SUMMARY.

Size, Inches.	Labor.	Material.	Fixed. Charges.	Total Cost. Net.	Adding for Culls 3%
4	$ 6.90	$ 6.31	$ 6.30	$19.51	$20.10
5	6.70	8.83	6.08	21.61	22.25
6	6.70	11.54	6.08	24.32	25.00
7	8.00	14.77	7.30	30.07	30.90
8	8.35	18.67	7.62	34.64	35.70
10	11.10	26.06	10.15	47.31	48.70
12	13.80	37.73	12.58	64.11	66.00

A plant in Iowa gives the following figures for 1,000 tile, based on a 1:4 mixture, though the prices of sand per yard, cement per barrel, and labor per day, are not given:

Size.	Cost per 1,000 Sand	Cement.	Labor.	Tot. Cost.	Selling Price.
4-inch	$ 1.25	$ 4.00	$ 4.25	$ 9.50	$ 21.00
5-inch	1.85	4.90	4.25	11.00	25.00
6-inch	2.60	8.75	4.25	15.60	34.00
8-inch	4.10	12.25	4.25	20.60	54.00
10-inch	5.25	17.50	7.00	39.75	90.00
12-inch	8.25	35.00	7.00	50.25	110.00

Still another manufacturer gives the following figures for 1,000 tile, based on a 1:4 mixture, with cement at $1.20 per barrel and sand at 25 cents per load.

Size.	Weight Per 1,000.	Cost per 1,000 Cement.	Sand.	Labor.	Tot. Cost.	Selling Price.
4-inch...	6,250	$ 3.10	$ 0.60	$ 7.50	$11.20	$16.00
5-inch...	8,500	4.25	.75	7.50	12.50	20.00
6-inch...	11,000	5.50	.85	7.50	13.85	25.00
7-inch...	14,500	7.25	1.25	10.00	19.50	35.00
8-inch...	18,500	9.25	1.75	15.00	26.00	45.00
10-inch...	25,000	12.50	2.30	20.00	34.80	65.00
12-inch...	35,000	17.50	3.30	30.00	50.80	95.00

Cost of 6-inch Tile. The following data is from a plant in Iowa using a power machine, rack system for curing, and belt conveyors for carrying away the tile:

Labor required—

1 foreman	$ 3.00
1 engineer	2.00
1 man running tile machine............	2.00
1 man at the mixer....................	1.50
1 man removing tile...................	1.50
3 skinners, $1.50 each................	4.50
1 man looking after sand elevator and screen and sprinkling tile...........	1.50
2 men in the yard with 1 horse each, $2.50 each	5.00
	$21.00

Assuming that 3,000 6-inch tile (the output of one day) require 13 yards of sand and 22 barrels of cement, we have the following costs:

Labor as above........................	$21.00
13 yards sand at $0.60................	7.80
22 barrels of cement at $1.50.........	33.00
	$61.80

This is a cost of $20.60 for 1,000 tile.

Overhead Expenses. Depreciation of plant should be figured at not less than 10 per cent, and interest on the investment at the prevailing interest rate. The items of repairs, insurance, etc., are hard to estimate, but figures

taken from a few plants seem to indicate that they run at about 12 per cent of the investment. On a plant valued at $5,000 this would give the following:

Interest on $5,000.00 at 6 per cent......	$300.00
Depreciation at 10 per cent..............	500.00
Repairs, insurance, etc..................	600.00
	$1,400.00

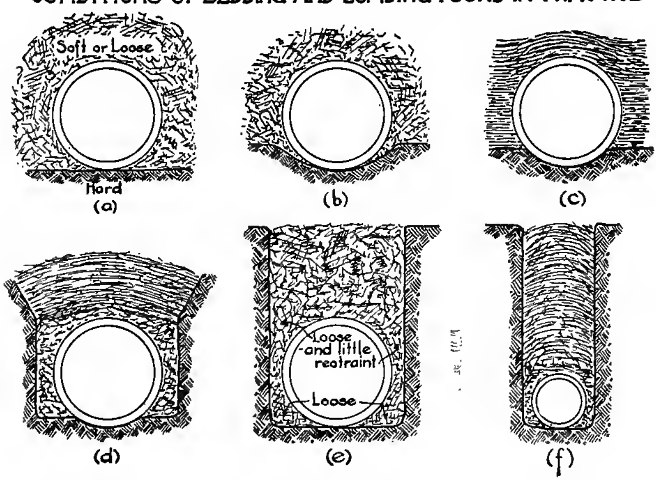
Care must be taken in spreading this expense to divide it by the actual or estimated number of days the plant runs, rather than the full number of working days in the year. This will also hold true of foreman's wages, where he is paid continuously, irrespective of whether the plant is running or not.

CHAPTER XI.

TESTS.

Conditions of Loading. The amount of the load and its distribution, and therefore the stress in the pipe, depends upon a number of conditions; the nature of the earth used in the filling, the method of bedding the pipe, the way of tamping the earth at the sides, the amount of lateral restraint or pressure of the earth horizontally, the method of filling and packing the earth above, the conditions of moisture in the earth, etc., all have an effect upon the amount of external pressure on the tile. Professor Talbot, in University of Illinois Engineering Experiment Station Bulletin No. 22, calls attention to the following ditch conditions: If the layer of earth immediately under the pipe is hard or uneven, or if the

CONDITIONS OF BEDDING AND LOADING FOUND IN PRACTICE



bedding of the pipe at either side with soft material is not well tamped, as indicated in Fig. (a), the main bearing of the pipe may be along an element at the bottom and the result is in effect concentrated loading, hence the tendency of the pipe to fail is greatly increased. In bedding the pipe in hard ground it is much better to form a trench so that the pipe will surely be free along the bottom element even after settlement occurs, and so that the bearing pressures may tend to concentrate at points, say, under the third points of the horizontal diameter (or even the outer ¼ points). This will reduce the tendency of the pipe to fail, as shown in Fig. (b).

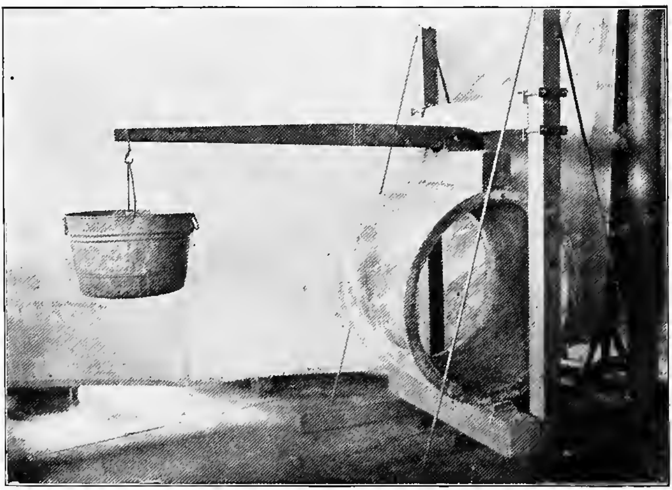
In case the pipe is bedded in loose material the effect of the settlement will be to compress the earth immediately under the bottom of the pipe more completely than will be the effect at one side, as indicated in Fig. (b), with the result that the pressure will not be uniformly distributed horizontally. Similarly in a trench if loose material is left at the sides and the material at the extremities of the horizontal diameter is loose, and there is little restraint, as indicated in Fig. (e), the pressure on the earth will not be distributed horizontally and the amount of stress in the pipe will be materially different from that where careful bedding and tamping give an even distribution of bearing pressure over the bottom of the tile. In case of a small tile in a deep trench the load upon it will be materially less than the weight of the earth above, as shown in Fig. (f), where the earth forms a hard, compact mass and is held by pressure and friction against the sides of the trench. If the large tile is held in a trench with sloping sides, as shown in Fig. (d), the load which comes upon the pipe will be materially less than the earth immediately above it. Should the sides of a deep trench cave, the pressure against the pipe will differ occasionally from that which obtains in the case of an earth filling as shown in Fig. (c).

Testing for Physical Properties. A number of elements enter into the choice of a suitable method of testing for physical properties of drain tile. (1) A definite and

important quality should be determined by the test. (2) The test should be simple, easily and quickly made, and should not require the services of an expert laboratory man. (3) The test should be of such a character as not to give unduly diverse results for test pieces of the same grade. (4) The machine to be used should be simple and inexpensive, easily adjusted to different sizes of specimen, and easily transported from point to point and easily made ready for use.

Illinois Testing Machine. This is a simple, portable testing device, designed by Prof. D. K. Abrams for use in the Laboratory of Applied Mechanics in the University of Illinois.

The machine consists essentially of a simple framework and a lever for applying the load by means of dead weight. The load applied through the loading lever may be blocks of iron, or stone, sand or other suitable material.



ILLINOIS TESTING MACHINE.

The main members are of timber; metal plates and other shapes are used at points of concentrated load and for connections.

Metal knife edges are provided for the bearing of the loading lever on the top loading block and for taking the upward thrust against the top cross block. The knife-edge bearings on the block over the test tile are 5 in. center to center, and a single knife edge takes the end thrust. This gives considerable freedom to the top loading block and allows the load to be fairly central, although the tile may be conical in outline.

The bottom loading block is provided with two small half rounds of hard wood placed about 2 in. apart, which allow the tile to seat itself in place. The load is applied at the top along a single element. Cushions consisting of short lengths of flattened rubber-lined fire hose serve to distribute the load along the length of the tile and prevent any local concentration of the load due to irregularities in the top and bottom surfaces.

The top cross block can be placed and held in any position along the uprights to accommodate the machine to any diameter of tile up to about 42 in. By this means the machine is adjustable to the greatest variation in the size of the test tile and will apply the load to all sizes under uniform conditions.

In order to check the dimensions of the loading lever, it was calibrated by setting a pair of platform scales in the machine and loading up to about 500 lb. on the machine. It was then placed in a 10,000 lb. testing machine and loaded up to 4,000 lb. The greatest error observed for this range of load was less than 1%.

This machine weighs 225 lb. It should not cost more than $15 to $18 in a shop equipped for wood and metal working.

An examination of this testing machine will show that it is simple in operation and that it is easily adjustable for different sizes. Tile which are out-of-round in different ways at the two ends will be easily taken by the machine and there is little chance for an unfair distribution of the load. The strip of hose gives some cushioning effect, and the load is practically distributed over the whole length in all cases. The method of loading along

a line at the top and bottom was selected because of its simplicity. The arrangement of the machine allows a tile to be rolled into place and to be easily made ready for test. It is believed that the results obtained by different operators will agree quite closely.

If desired the modulus of rupture of the material may be determined from the bending moment developed and the dimensions of the pipe. For general purposes it will be preferably to report the load per foot of length of pipe for a given size. Possibly for some purposes it may be interesting to divide this load by the diameter of the pipe in inches and thus compare the results per inch of diameter for a pipe one foot long.

It has seemed the simplest way to fix at a definite distance apart the two strips on which the tile rests. An analysis of rings shows that when the bearing on these strips are 2 inches apart the formula for the bending moment will be but 2½ per cent different from that for a single support for tile 6 inches in diameter and ¼ of 1 per cent for a tile 12 inches in diameter, while for larger sizes this variation will be much less. Under the conditions of such tests it would seem better to fix the distance for these strips and use a common expression for the formula for the bending moment for all sizes of tile to be tested. It would seem that 0.16 Qd is a satisfactory expression for the bending moment where Q is the concentrated load applied at the crown and d is the mean diameter of the tile. For the modulus of rupture (f) of the material the formula would be

$$f = 0.96 \frac{Qd}{lt^2}$$

where l is the length and t the thickness of the tile along the top and bottom elements.

Duplication of Actual Conditions Not Considered Essential. This method of testing was selected in preference to a method involving the bedding of the tile in sand or other material, because of the difficulty in embedding large tile in sand in such a way as to obtain a fair distribution of

pressure and in securing the same distribution of pressure in different tests and because the method of concentrated loads will give a more definite index of the strength of the material. Professor Abrams says that in tests of materials it is not essential that the material shall be subjected to the same action in the process of testing that it will receive in service. The cold bend test of steel is one of the most useful and instructive tests, but it differs radically from any condition of service in which the steel will be placed. The value of a test will depend upon the properties determined. In testing drain tile the method of applying concentrated loads has many advantages over that of applying distributed loads. Whatever the method of testing used, it will be neeessary finally to determine the relation between strength of the test piece and the strength which is needed in the structure. In the case of tile to be used in a ditch of a given depth and a given soil the necessary test strength will have to be determined. Since the tests will have to be translated into the working conditions, it would seem not necessary to attempt to make the conditions like the conditions in the ditch. It is of much more importance that the tests should be simple, direct and fairly uniform under varying conditions of tile and with different machines and different operators. Our own experience with this machine leads us to think that it would make a satisfactory means of determining the quality of drain tile.

Four Compression Tests. Compression tests on four specimens of concrete drain tile were made February 16, 1910, at the Laboratory of Applied Mechanics of the University of Illinois, with the following result:

Inside Diameter Inches	Average Thickness of Walls, Inches	Length Inches	Maximum Load, Pounds	Load, Per Linear Foot, Pounds	Load, Per Square Foot, Pounds
8	¾	12.2	500	495	730
10	⅞	12.2	1170	1150	1380
12	1	12.3	1270	1240	1240
16	1½	12.3	1200	1170	860

Each test piece had six circumferential corrugations about $\frac{1}{8}$ in. in height, spaced 2 in. apart.

The load was applied along the top and bottom elements of the tile through cushions of heavy rubber belting. An adjustable bearing block was used.

All specimens failed by cracking longitudinally along either the top or bottom elements. Later they cracked along the elements at the horizontal diameter at a lower load.

In computing the loads per square foot carried in the last column above, the internal diameters of the tiles were used.

Test of 10-foot Concrete Pipe. In the latter part of 1910, a circular pipe 10 foot in diameter was given an exhaustive test by Professor C. J. Tilden, of the University of Michigan.

This pipe had walls 10 inches thick and was constructed in a rather unusual manner, being built up of individual segmental blocks or slabs, each slab about 5 feet long in the direction of the axis of the pipe and about $3\frac{1}{2}$ feet wide. These blocks are formed to segments of a circle so that 10 are required to complete a circular section. The sections have tongues and groove joints in both directions.

In making the test, the lower half of the section, which was 20 to 25 feet long, was buried in the ground while the upper half stood practically clear of the ground and carried the superimposed load of pig iron. The pig iron was piled by hand upon a specially constructed saddle, spanning about 125 degrees of the top half of the pipe. This saddle consisted of strips of sheet steel $\frac{1}{8}$ inch thick, bent over the top of the pipe and attached at either side to the bottom of a heavy plank side piece, made up of three 3x12-inch oak planks each ten feet long. The tops of these side pieces were connected by $4\frac{1}{2}$x$\frac{3}{4}$-inch flat bars, passing over the top of the pipe, the whole saddle thus forming a staunch receptacle for the load.

Professor Tilden thus gives the story of the test, its results and the lessons to be learned from it:

"The load thus applied to the structure, while it ap-

proximates the conditions of actual practice, is in reality a more severe test than is likely to occur under any ordinary conditions of earth pressure if the pipe were buried in the ground.

"The upper half of the pipe thus carried the heavy load placed upon it after the manner of an arch. When the writer first inspected the pipe on November 25, 1910, it was carrying a load of about 15 tons, and no deflection had been noted under this load. During the writer's stay on the ground the load was increased to a total of nearly 50 tons still without causing any deflection that could be detected. A slight crack in the mortar of one of the joints was noticed at an early stage of the loading. This, however, did not extend the entire length of the pipe and as it did not open appreciably during the subsequent loading it is improbable that it was due primarily to the load. It may have been a shrinkage crack in the mortar of the joint, or a crack resulting from some slight unevenness in the joint which adjusted itself during the early stages of loading. The fact, however, that it did not increase enough to be detected under the heavier subsequent loading indicated that it had little or no effect on the strength of the structure. On the day following the writer's visit the loading was continued until it reached a total of over 158,000 pounds or nearly 80 tons, being an average for the length of ten feet of nearly 8 tons of load per running foot of pipe. When it is considered that the load is somewhat irregular in shape and heaped up into a rough pyramid in the center, it is fair to assume that some parts of the pipe, at least, are carrying a load whose intensity is fully 8 tons per running foot of length. It is further worthy of note that this loading is not exactly central, the center of gravity of the pile of iron being a little to the left of the vertical center line. This eccentrity, although slight, would cause somewhat higher stress than if the load were centered accurately.

While it is not possible to compute the exact value of the unit stresses in a structure of this kind under the

loading shown, a fair approximation to these values may be made on the basis of accepted theories. The writer has made various computations of this sort for several points on the circumference of the pipe, assuming different conditions as to the distribution of the load over the top and finds that the maximum intensity of compressive stress is probably nowhere in excess of 300 or 400 pounds per square inch. A concrete of such quality as was used in these blocks can safely withstand 600 to 700 pounds per square inch, and has an ultimate strength, in compression, of 2,000 pounds per square inch, or more. The tensile stresses are probably wholly insignificant; if they occur in the body of one of the segmental blocks, the reinforcing wire is amply able to carry them, and even at a joint it is not likely that a tension is developed higher than good cement mortar can safely withstand.

It is the opinion of the writer that the stresses resulting from the load of pig iron are probably much more severe than if the pipe were buried in the ground to a depth of 12 or 15 feet.

The conclusions arrived at may be stated as follows:

(1) That the structure is especially well adapted to meet any conditions of loading that are likely to be imposed upon it.

(2) That it would probably carry safely—that is, without developing excessive stresses—a greater load than 158,379 pounds.

(3) That the load of 158,372 pounds is a much more severe test of structural strength than any which the pipe is likely to receive under service conditions.''

Original Iowa Tests. The tests as carried on at the Engineering Experiment Station of Iowa State College are still of value, although the manufacture of concrete drain tile has made much progress since that time. The result of these is as follows:

Tests of 4 to 20-inch Cement Tile.

Propor. C.	Propor. S.	Dimensions, ins. L.	Dimensions, ins. D.	Dimensions, ins. T.	Str. load per lin. in. 2 months.	Str. load per lin. in. 11 months.	Remarks.
1	3	24	20	2¼	89	69	Cracked
1	3	24	20	2¼	73		
1	3	24	20	1¾	68	142	
1	3	24	20	1¾	70	175	1½ in. shell.
1	3	24	18	2¼	115	315	2 in. shell.
1	3	24	18	2¼	141	299	2 in. shell.
1	3	24.	18	1¾	109	221	1½ in. shell.
1	3	24	18	1¾	79	81	Cracked.
1	3	24	12	2	116	365	
1	3	24	12	2	155	470	2¼ in. shell.
1	3	24	12	1½	135	181	
1	3	24	12	1½	99	218	
		24	12	1½	95		
		24	12	1½	125		
		24	12	1¼	58		Under tamped.
1	5	12	12	1	98		
1	5	12	12	1	115		
1	4	12	10	⅛	106		
1	4	12	8	¾	97		
1	4	12	8	¾	71		
1	4	12	8	¾	74		
1	5	12	7	¾	99		
1	5	12	7	¾	177		
1	6	12	6	⅝			
1	5	12	6	⅝	66		
1	5	12	6	⅝	73		
1	3	12	5	⅝	97		
1	5	12	5	⅝	82		
1	5	12	4	⅝	98		
1	5	12	4	⅝	80		

Result of Tests. The results of the tests are shown in the tables herewith. In these tables C means cement, L length, S sand, D diameter and T thickness.

Shortly after these tests were completed Professor Marston summarized them in an address before the Iowa Association of Cement Users, published in the Iowa Engineer of March, 1908, in which he said:

"In attempting to draw conclusions from these results, it should be remembered that tests of clay and cement materials show large variation due to unavoidable differences in manufacture, and hence not too much reliance should be placed upon the results of so small a number of tests as are given in the above tables. Perhaps the most striking feature in connection with these tests is the great increase of strength from two months to eleven months in the age of the cement tile manufactured at the college. In this connection it should be remembered that the weather was cool during the first two months these were cured. The increase in strength is shown in the table following:

Per cent of increase in strength of cement drain tile between the age of two months and eleven months.

Diameter—	Per Cent of Increase.
20 in. thin	130
18 in. thick	140
18 in. thin	136
12 in. thick	205
12 in. thin	71

"One good quality of cement drain tile is that they continue to increase in strength after first manufactured. Unfortunately, however, the heaviest pressures come upon them soon after they are laid. It would not seem wise, therefore, to use cement tile very soon after manufacture.

"Theoretically the strength of cement drain tile per lineal inch should be in proportion to the square of the thickness of the shell. In these tests this law is obscured, possibly by variations of the strength due to other causes than thickness.

"It is altogether probable that in an extensive series of tests the strength would be found more nearly proportionate to the square of the thickness of the shell.

"It has already been stated that theoretically the strength of tiles of the same diameter will be in proportion to the square of the thickness. With the same load the strength theoretically should be inversely proportional to the diameter for equal thickness. Neglecting the friction of the trench filling against the sides of the ditch, the load would be approximately proportional to the diameter. Putting these factors together, we would find some cause to believe that thickness of drain tile should be proportional to the diameter of the pipe, for equal resistance to the pressures coming upon them.

"Our experience in making this series of tests has convinced us of the very unsatisfactory character of the results made on samples of cement tile collected at random here and there around the state as a basis for scientific investigation. While such tests may be useful to get some idea of the character of the tile now being made,

they may vary greatly owing to mistakes or carelessness in manufacture which cannot be made a matter of record. For example, in comparing the different proportions of sand and cement reported in one of the tables, we cannot be sure that the small portions of mortar out of which the individual tile happened to be made were really of the proportions indicated, nor can we be sure that the tile received the same treatment in curing.

"Hence the only comparison between cement and clay drain tile which we feel warranted in making at this time is in the case of the cement tile manufactured by ourselves. A comparison of the tests of these tile with those of corresponding diameters of clay tile is here given.

Comparative average strength of cement and clay tile.

Internal diam., inches.	Cement Tile. Age 2 months. Thickness (inches)	Strength (lbs. per lin. in.)	Age 11 months. Thickness (inches)	Strength (lbs. per lin. in.)	Clay Tile. Thickness (inches)	Strength (lbs. per lin. in.)
24					2⅛	318
20	2¼	81				
20	1¾	69	1⅝	159		
18	2¼	128	2	307		
18	1¾	94	1½	222	1¼	200
15					1	103
12	2	137	2⅛	417	1⅛	158
12	1½	117	2½	200	⅞	141

"A study of this table will convince any one that it is feasible to make cement drain tile which will attain all necessary strength and which will compare very favorably in this respect with clay tile."

Tests in Brooklyn. The following tests of concrete pipe are given by Mr. Homer A. Reid in "Concrete and Reinforced Concrete Construction":

Size and description—	Thickness	Breaking weight.
12-inch round flat base	1 1/16	10,624 lbs.
18-inch egg flat base	1⅝	*18,785 lbs.
18-inch egg flat base	1⅝	12,287 lbs.
18-inch egg flat base	1⅝	†13,190 lbs.
24-inch egg flat base	2	26,547 lbs.

*Cracked at 10,155 pounds; additional required to crush.
†Cracked at 9,717 pounds; additional required to crush.

Some clay pipe tests at the same time showed the following results:

In making these tests, a wooden beam 20 feet long was used, with a 2-foot fulcrum. The pressure was applied to a saddle having a rubber gasket between it and the pipe, so as to give the saddle an even bearing and thus do away with any concentrated pressure.

Size and description—	Breaking weight.
12-inch double-strength shale	7,756 lbs.
12-inch single-strength vitrified	7,544 lbs.
12-inch standard Akron (average of 3)	5,500 lbs.
12-inch vitrified	7,859 lbs.
18-inch Akron double-strength	8,842 lbs.

Pipe Used on Irrigation Work. For many years buried cement pipe has been used for the distribution of irrigating water in southern California. It is ordinarily considered safe for heads of water up to 14 feet, according to S. M. Woodward of the United States Department of Agriculture, who gives the following results of scattering tests:

Two lengths of 16-inch pipe, united with a cement joint three weeks old, did not break under a head of 20 feet, or 9 pounds per square inch. A 10-inch pipe broke under a head of 20 feet. An 8-inch pipe did not break under a head of 46 feet, or 20 pounds per square inch. A line one-half long of 10-inch pipe, specially made of a 1 to 2 mixture, carries constantly a head of 20 feet.

Reinforced Pipe at Pueblo, Colo. More than 18,000 linear feet of hub and spigot concrete pipe, in 30 and 38-inch sizes, was made in connection with the development of a water system at Pueblo, Colo., as described in The Engineering Record for April 4, 1908. This pipe was all in 2-foot lengths, the shell of the 38-inch size being 3¼ inches, and that of the 30-inch size, 2½ inches thick. The concrete was made in the proportions of 1 part Iola Portland cement to 4½ or 5 parts of gravel obtained from the river, depending on the percentage

of voids in the gravel. The latter was of excellent character for the purpose, varying from sand to stone that would pass a ¾-inch screen. The concrete was all mixed by hand, and was thoroughly hand-tamped in the molds in which the pipes were cast. The resulting pipe was of excellent quality, as was determined by a number of tests made shortly after the manufacture of the pipe was commenced.

Each section tested was first placed in a hole and imbedded, nearly up to the springing line, in sand. A platform, supported by four saddles made of 1½-inch oak, and equally spaced on the section, so as to fit closely across the top of the pipe, from springing line to springing line, was then loaded with cement sacks until the pipe failed, or at least showed signs of failure, since it was impossible to destroy some sections with the loads available. After the first two sections had been tested in this manner it was evident that the saddles fitted so closely at the springing lines that the pipe in crushing had no opportunity to spread at these points, a condition which would scarcely have obtained in actual service. The under edges of the saddles were, therefore, cut away until they did not rest on the pipe for about 4 inches above the springing line on each side. About twenty plain and reinforced sections were then tested to determine their safe and ultimate carrying capacities. The pipe, when tested, was from 15 to 26 days old. Rings of round ⅜-inch iron rods, barbed wire, and annealed round wire were used in the reinforced sections tested. The ⅜-inch rods gave the best results, but were too expensive for the purpose. The annealed round wire produced better results than the barbed wire, and as the pipe reinforced with the round wire had sufficient strength, this wire was accordingly used in all of the pipe that was reinforced. The results of the tests were fairly uniform, and demonstrated that pipe reinforced with seven No. 5 wires in each 2-foot section could safely be used in the trenches over 12 feet deep; and that plain pipe had ample strength for the balance of the work. The section of the flow line

in which concrete pipe was used is also built of plain pipe, the maximum head of this section being 7 feet. This section of the line has been perfectly satisfactory in service.

German Tests. The following summary of results is taken from a detailed report of results of a test of clay and cement pipe made in 1907 by Burchartz and Stock, of the Royal German Building Material Testing Department:

Inside diam., inches.	Thickness of Shell, Inches.		Resistance Against External Pressure, Pounds		Resistance Against Internal Pressure, Atmospheres.	
	Clay.	Cement	Clay.	Cement.	Clay.	Cement.
8	0.92	1.40	4,330	4,550	17.9	8.8
12	1.04	1.92	5,960	9,510	11.9	2.3
16	1.12	2.16	7,280	8,120	9.6	..
18	1.28	2.24	4,510	8,050	9.3	..
20	1.44	2.44	7,720	6,750	10.6	2.9
24	1.72	2.80	6,490	7,960	7.2	..
28	1.88	3.20	7,210	10,120	8.7	2.7
32	1.96	3.40	7,000	7,170	7.7	..

Tests for Loss of Cement in Solution. A few tests to ascertain the loss in weight of drain tile through the solution of its cement bond are described by Mr. A. O. Anderson of Lake City, Iowa, in Engineering-Contracting for December 9, 1908. For the purpose of this test, specimens from drain tile of various ages were thoroughly dried, brushed with a stiff bristle brush to remove all loose particles, weighed, and then placed in boiling water which was changed at intervals of one hour during the test. After being boiled for different periods, the specimens were dried, weighed and then replaced in water again for a longer interval of time. As the test pieces were subjected to the mechanical as well as the chemical action of boiling water, a loss from abrasion as well as from solution may occur. Results from two different series of tests are herewith given:

SERIES I.

No.	Original Dry Weight	Weight after boiling 1 hour.	Weight Weight after boiling 7 hrs.
16	75.450 g.	74.780 g.	75.260 g.
24	53.520 g.	53.112 g.	53.305 g.

No. 16 is from a 16-inch cement tile; age about 60 days; mixture 1 to 3½, new.

No. 24 is from 24-inch cement tile; age about 2 years; mixture 1 to 4. This tile has laid along line of ditch for about two years.

SERIES II.

No.	Original Dry Weight.	Weight after boiling 1 hour.	Weight after boiling 5 hrs.	Weight after boiling 15 hrs.
A2	27.800 g.	27.604 g.	27.865 g.	27.860 g.
A3	23.422	23.480	23.520	23.688
A5	28.605	28.516	28.685	28.955
A7	33.815	33.855	33.997	34.030

A2 and A3 are from 20-inch and A5 and A7 from 18-inch cement drain which have been installed about four years.

An examination of these results will show that at the end of the first hour's boil, the decrease, if any, occurs, and upon further boiling the weight actually increases.

Mr. Anderson considers the loss in weight due to the fact that the cement has a certain amount of gypsum or other soluble substance mixed with it, which, with the free lime which the cement may contain, will be lost during the early stages of boiling. As the tile from which the specimens in Series I were taken are comparatively new and had not been subject to the action of percolating water, a larger decrease in weight is obtained than from those used in Series II, which have been used for drainage purposes for several years and probably had lost the greater part of their soluble components.

The increase in weight which is secured upon prolonged boiling may be due to the variation in size of grains in

Portland cement. The rapidity of chemical action is dependent upon temperature and size of grain, the time and moisture being constant. "As but half of 'market' cement is supposed to be ground fine enough to possess setting qualities under normal conditions," says Mr. Anderson, "the remainder will probably hydrate if kept in contact with moisture for a sufficient length of time or if subjected to a high temperature for a shorter interval of time. The specimens being subjected to the hot water, it is probable that many particles hydrated which because of their size are not able to take up water and set under normal conditions."

Experiments in Arizona. As a result of work done at the Arizona Experiment Station, G. E. P. Smith of that institution says that cement pipe for small irrigating ditches is from every point of view to be recommended.

With a view to determining the best mixtures and the cost of cement pipe in the Santa Cruz valley, a molding outfit was secured and some experimental pipes were made. The size selected was of 15 inches diameter, and several lots of pipe were made of a mixture of 1 part cement to 3½ parts unscreened arroyo sand. There were ten 2-foot lengths, each hard and strong, of perfect shape and representing a cost of only 38½ cents per lineal foot. The amount of cement used was five sacks.

The fourth lot was made of a very lean mixture of cement, lime paste and sand. The replacement of a part of the cement by lime was made for the double purpose of reducing the cost and obtaining a denser and more impermeable pipe. The paste was thinned to a consistency that permitted it to mix thoroughly with the sand, and the bell ends were made of a mixture of 1 part of cement to 3 parts of sand. The results were very satisfactory.

The fifth and sixth lots were made in another locality, and the sand and gravel were of a different character from those used previously, so that screening was necessary. All above one-half inch in size was rejected.

There is a difference of opinion, says Mr. Smith, in

regard to the shape of the small tile and the kind of a mold to be used. In California the bevel and tongue joint is used. It is quickly molded and quickly laid. The bell and spigot joint is liable to suffer injury to the bells, but will probably be laid with tighter joints than the beveled end pipe, especially by an inexperienced person.

Head of Water Sustained for Various Mixtures. The following tables give the results of tests made by Mr. Daniel Scoates to ascertain the head of water which concrete tile will stand, and the mixture best adapted for making pipe to be used under pressure.

A cement was used which had passed the standard specifications, with good clean gravel that was screened through a ½-inch mesh sieve. It was hand mixed and just enough concrete mixed at one time to keep the molds going. Two mixtures were used—1 part cement to 2 parts gravel, also 1 part cement to 3 parts gravel. The amount of moisture was varied, both wet and dry mixtures being used. By dry mixture is meant such a condition that as soon as the tile is tamped in the molds the mold can be removed and the tile will stand. A wet mixture is considered as having enough water in the concrete to make it sloppy; this is put in the molds and allowed to stand 12 hours before mold is removed.

The molds were the common hand type which have a

TABLE 1

Dry Mixture; 1 cement to 2 gravel; 9 months old; straight joints.

Diameter (Inches)	Thickness of pipe (Inches)	Bursting Pressure (Lbs. per Sq. in.)	Time	REMARKS
8	$1\frac{3}{16}$	20	30 sec.	Washed inside with neat cement
8	$1\frac{1}{8}$	45	3 min.	
8	$1\frac{1}{8}$	30	30 sec.	Washed inside with neat cement
10	.....	.....	15 lbs. for 3 min.	Joints faulty
10	$1\frac{3}{16}$	20	14½ lbs. for 3 min.	Broke on top
12	.....	.....	15 lbs. for 3 min.	Joints faulty
12	.....	.....	20 lbs. for 3 min.	Joints faulty
12	.....	.....	9½ lbs. for 3 min.	Joints faulty

TABLE 2

Dry mixture; 1 cement to 2 gravel; 9 months old; T and G joints.

Diameter (Inches)	Thickness of pipe (Inches)	Bursting Pressure (Lbs. per Sq. in.)	Time	REMARKS
8	1⅛	24	½ min.	Broke through joint
8	1 5/16	30	1 min.	Washed inside with neat cement
8	1⅛	34	23 lbs. for 5 min. 34 lbs. for 2 min.	Washed inside with neat cement
10	.....	.....	6 lbs. for 3 min.	Joints faulty
10	1⅜	20	1 min.	Broke on top
10	.....	.....	20 lbs. for 3 min. 22 lbs. for 3 min.	Highest pressure could get in this tile
12	1⅜	20	15 lbs. for 3 min. 20 lbs. for ½ min.	Broke on top
12	1⅜	4	1-6 min.	Broke on side
12	1⅜	6	1-6 min.	Broke on side

TABLE 3

Dry mixture; 1 cement to 3 gravel; 9 months old; straight joints.

Diameter (Inches)	Thickness of pipe (Inches)	Bursting Pressure (Lbs. per Sq. in.)	Time	REMARKS
8	1⅛	15	1 min.	Broke on side
8	1 3/16	20	14½ lbs. for 3 min. 20 lbs. for 2⅛ min.	Broke on side
8	1 3/16	30	15 lbs. for 3 min. 20 lbs. for 3 min. 25 lbs. for 3 min. 30 lbs. for 3 min.	Broke on side
10	1⅜	24	15 lbs. for 3 min. 24 lbs. for 10 min.	Broke through joint
10	1 5/16	20	15 lbs. for 3 min. 20 lbs. for 10 min.	Broke on bottom
10	5 5/16	14½	1-6 min.	Broke on side
12	1 7/16	9½	½ min.	Broke on bottom
12	1⅜	13½	10 lbs. for 3 min. 10½ lbs. for ½ min.	Broke on side
12	1 9/16	12½	1-6 min.	Broke on side

TABLE 4

Dry mixture; 1 cement to 3 gravel; 9 months old; T and G joints.

Diameter (Inches)	Thickness of pipe (Inches)	Bursting Pressure (Lbs. per Sq. in.)	Time	REMARKS
8	1⅛	20	14½ lbs. for 3 min. 20 lbs. for 1 min.	
8	1 3/16	20	14½ lbs. for 3 min. 20 lbs. for 1-6 min.	
10	1 5/16	6	1-6 min.	Broke on side
10	1 5/16	25	15 lbs. for 3 min. 20 lbs. for 3 min. 25 lbs. for 1½ min.	Broke through joint
10	1¼	9½	1-6 min.	Broke through joint
12	1 7/16	6½	1-6 min.	Broke on top
12	1 7/16	8½	1-6 min.	Broke on top
12	1 7/16	9½	1-6 min.	Broke on top

TABLE 5

Wet mixture; 1 cement to 2 gravel; 6½ months old; straight joints.

Diameter (Inches)	Thickness of Pipe (Inches)	Bursting Pressure (Lbs. per Sq. in.)	Time	REMARKS
8	1 3/16	20	15 lbs. for 3 min. 20 lbs. for 3 min.	Broke on top
8	1⅛	24	½ min.	Broke on top
10	1⅜	23	14½ lbs. for 5 min. 23 lbs. for 1-6 min.	Broke on top
10	1⅜	16½	14½ lbs. for 3 min. 16½ lbs. for 1-6 min.	Broke on top
12	1 5/16	14½	1-6 min.	Broke on top
12	1½	20	1-6 min.	Broke on top

collapsible core. The tile were well cured for one month, allowing them to have all the moisture they could take up. Then they were laid in rows of four tile in a row—each row being considered one break or one test. The tile were placed one-third in the ground so as to insure a steady bearing.

In laying these tile two forms of joints were used. The straight joint, which consisted of having flat ends on the tile and placing them together, then plastering over the joints with a 1 to 1 cement mortar, to a thickness of 1 inch and a width of 3 inches; the other form of joint was the tongue and groove, plastered with mortar about ½ inch thick and 1½ inches wide.

The apparatus for breaking consisted of two bulkheads which fitted over the ends of the tile, the water being supplied through one end while a pressure gauge was placed at the other end.

Working along these lines the results were obtained as given in tables 1 to 5.

Where no bursting pressure is given the tile failed to break. Under "Time" is given the duration of time of some of the pressures.

To take up the general results that are to be drawn from this investigation, one thing impressed itself far above all others—and that is that the dry mixture tile are too porous. Water would go through them in small streams at a five-pound pressure. If this kind of tile is used at all they must be treated. The painting on the inside with neat cement was tried; this helped but still they leaked. In California it is claimed that good results are obtained by using this method and doing it as soon as the tile has reached its final set. The wet mixture tile were practically water-tight. To make the tile with a wet mixture of course calls for a larger number of molds, but the improved product will pay for the additional outlay.

In order to test the amount of water that would seep through the wet mixture tile, one line was allowed to stand with a 5-pound pressure on it for some time, then broken; it was found that the outside surface was perfectly dry and the water had only soaked through one-fourth of the thickness of the tile. In each case when the wet mixture broke they did so with a loud report.

The results from the tables show that as far as the mixture goes the 1 to 3 (dry mixture) gave results near

enough to the 1:2 to make it the best proportions for use. In the wet mixture 1 to 2 was the only one used, but from the general results a 1 to 3 would be the better, because of the cost.

Table 5 indicates a fair factor of safety and would be a reasonably safe proposition to use in the design of an irrigation system. For it must be remembered that these tile were broken on the top of the ground and the majority of them broke on the top and sides. So if they are placed in the ground it is reasonable to suppose that the pressure of the earth around them will tend to help take care of the internal pressure.

Good Test after Twenty-eight Years. A cement drain tile cast in 1883 and in service for twenty-eight years from that time was the subject of an interesting test at the Chicago Cement Show of 1911. The tile was taken from the farm of Mr. Howard Fitz, at Monterey, Minn. It was 4 inches in diameter, 11¾ inches long, with a wall thickness of 1½ inches and not different from hundreds of others that are still serving as an efficient drainage system. The tile was imbedded in plaster between two wooden saddles, one above and another below, each covering one-third of the area. The tile gave way at 31,220 pounds. It showed the remarkable strength that may be expected from well made tile and also the fact that cement tile does not deteriorate with age, as this specimen had seen twenty-eight years of service.

Iowa Specifications. These specifications for testing have been suggested by Prof. A. Marston of the Iowa experiment station and were adopted by the Iowa Cement Users Association and the Iowa Society of Engineers:

1. *Specimens.* The specimens shall be each approximately two inches square, and shall extend the full thickness of the pipe wall, with the outer skins unbroken.
2. *Number of Test Specimens.* Five individuals tests shall constitute a standard test, the average of the five, and the result for each specimen, being given in the report of the test.
3. *Drying Specimens.* Each specimen shall be dried in an oven or by other application of artificial heat, until they cease to lose further appreciable amounts of moisture when repeatedly weighed.

4. *Brushing Specimens.* All surfaces of the specimens shall be brushed with a stiff brush before weighing the first time.

5. *Weighing.* The specimens shall be weighed immediately before immersion, on a balance or scales capable of accurately indicating the weight within one-tenth of one per cent.

6. *Water for Standard Test.* The water employed in the standard absorption test shall be pure soft water, at the air temperature of a room which is artificially heated in cold seasons of the year.

7. *Immersion of specimens.* The specimens shall be completely immersed in water for a period of 24 hours.

8. *Re-weighing.* Immediately upon being removed from the water, the specimens shall be dried by pressing against than a soft cloth or a piece of blotting paper. There shall be no rubbing or brushing of the specimen. The re-weighing shall be done with a balance or scales capable of accurately indicating the weight within one-tenth of one per cent.

9. *Calculation of Result.* The result of each absorption test shall be calculated by taking the difference between the initial dry weight and the final weight, and dividing the remainder by the initial dry weight.

Specifications for Standard Tests of Bearing Strength.

1. *Specimens.* The specimens shall be unbroken, full sized samples of the pipe to be tested. They shall be carefully selected so as to represent fairly the quality of the pipe.

2. *Number of Specimens.* Five individual tests shall constitute a standard test, the average of the five and the result for each specimen being given in the report of the test.

3. *Drying.* The specimens shall be dried by keeping them in a warm, dry room for a period of at least two days prior to the test.

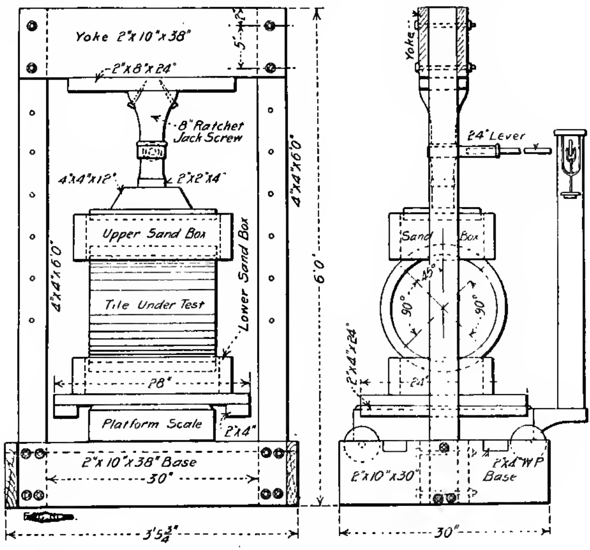
4. *Weighing.* Each dried specimen shall be weighed on a pair of reliable platform scales just prior to the test.

5. *Bedding of Specimens for Test.* Each specimen shall be accurately marked, with pencil or crayon lines, in quarters, prior to the test. Specimens shall be carefully bedded above and below in sand for the one-fourth circumference of the pipe, measured on the middle line of the tile wall. The depth of bedding above and below the title at the thinnest point shall be equal to one-fourth the diameter of the pipe, measured between the middle lines of the tile walls.

6. *Top Bearing.* The top bearing frame shall not be allowed to come in contact with the tile or with the test load. The upper surface of the sand in the top bearing shall be made level and shall be carefully covered with heavy cross plank or timbers capable of uniformly distributing the test load without any appreciable bending. On top of these cross planks or timbers shall be placed a heavy longitudinal timber capable of distributing the load to the cross timbers without any appreciable bending. The test load shall be applied at the exact center of this top timber in such a way, either by the use of a spherical bearing, or by the use of two rollers or rods at right angles, as to leave the timber free to move in both directions. In case the test is made without

the use of a machine, and by piling on weight, the weight may be piled directly on a platform resting on the cross timbers, provided, however, that the weight does not touch the top frame holding the sand, and provided, further, that the weight is piled in such a way as to insure uniform distribution of the load over the top surface of the sand.

7. *Frames for Top and Bottom Bearings.* The frames for the top and bottom bearings shall be composed of timbers so heavy as to avoid any appreciable bending by the side pressure of the sand. The frames shall be dressed on their interior surfaces. No frames shall come in contact with the tile during the test. A strip of soft cloth may be attached to the inside of the upper frame on each side along the lower edge to prevent the escape of sand between the frame and the tile.



IOWA TESTING MACHINE.

8. *Sand in Bearings.* The sand used for bedding the tile at top and bottom, shall be material which has passed a No. 8 screen and has been retained on a No. 16 screen. It shall be dried by keeping it spread out thin in a warm, dry room.

9. *Application of Load.* The test load shall be applied gradually and without shock or disturbance of the tile. The application of the load shall be carried on continuously, and the tile shall not be allowed to stand any considerable length of time under a load smaller than the breaking load.

10. *Calculation of the Bearing Load.* The total breaking load shall be taken as equal to the total top load, including the weight of top frame, sand for top bearing, top bearing timbers, etc., plus five-eights of the weight of the pipe. This total load

shall be divided by the length of the pipe in feet so as to give the bearing strength per linear foot of pipe.

The modulus of rupture for drain tile and sewer pipe shall be computed from the results of the standard test for bearing strength, according to the following rule:

Divide the bearing strength per linear foot by 12, multiply the quotient by the radius of the middle line of the tile wall expressed in inches, and divide this product by the square of the minimum thickness of the tile wall at top or bottom, also expressed in inches. This quotient will be the modulus of rupture of the pipe expressed in pounds per square inch.

CHAPTER XII.

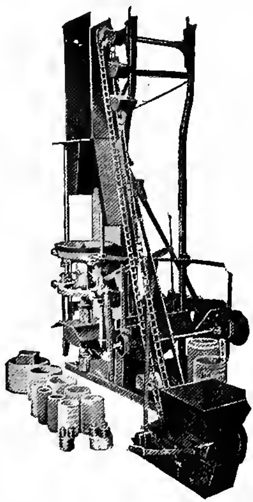
The Machines and Systems on the Market.

No better evidence of the rapid development of interest in cement pipe and tile can be given than to cite the large number of machines which have come onto the market within very recent times. We shall endeavor in this chapter to give sufficient data regarding each of these machines to give a man who is contemplating going into the business a general idea of the characteristics of each.

The Besser Power Cement Drain Tile and Sewer Pipe Machines. The Besser Manufacturing Company, Alpena, Mich., manufactures two radically different types of machines for this class of work. One of these follows very largely the old established lines of drain tile machine, having a revolving packer which packs the tile automatically in the galvanized iron jacket. This machine manufactures tile from 3 to 16 inches in diameter and lengths of either 12, 18 or 24 inches. It is claimed that it will make 3,000 tile per day with three men, or 4,000 tile with four men. A double machine is also made of the same general type, but duplicating the working parts, which is claimed to make 7,000 tile per day. The frame of this machine is cast in one piece and is very compact. The boot is so arranged that a continuous mixer can dump directly into the feed hopper. The automatic feed can be stopped and changed instantly for the different sizes of tile. In this machine the packer is stationary, the frame which carries the casing moving up and down around the packer. The sliding parts are made adjustable to wear. The packer shaft projects from below, carrying the packer on top of the shaft.

The other machine is of an entirely different design and is intended for large drain tile and sewer pipe, its

capacity being pipe from 18 to 40 inches in diameter and in lengths of 24 or 30 inches. It makes these with either plain end, bell end or socket joint. No pallets are used for any of these and the molds are removed immediately. This is an automatic tamper machine with four tampers



working up and down between the revolving core and the casing. They strike, combined, 450 blows per minute with a force of 400 pounds to each blow. This machine is operated by one man. This machine can also be secured with two tables for any size up to 18 inches in diameter.

Cardiff Cement Tile Machine. This is a hand machine, made by the Leavitt Manufacturing Company, Urbana, Ill. This is a low priced machine making tile 12 inches long and 4 to 12 inches in diameter at the rate of 500 to 750 per day. The operation of this machine is described as follows: Place a mold on the face plate, raise the core, swing the hopper in place and fill up the mold with cement. Take hold of the hand wheel and work it backward and forward, working the tamper up and down. After three or four strokes put in some more. Turn the

tamper up in place swing the hopper around and strike off the top of the tile. Then drop the core and take hold of the mold with both hands and carry it to the curing rack.

Crescent Power Tile Machine. The manufacturers of this machine are Raber & Lang Manufacturing Company, of Kendallville, Ind. It can be used for making tile from 3 to 12 inches in diameter and in 12-inch lengths. It occupies a floor space of 3x4 feet, 7½ feet high. It has a sliding frame which carries the jackets under the packer, this packer being located at the center of the

CRESCENT TILE MACHINE.

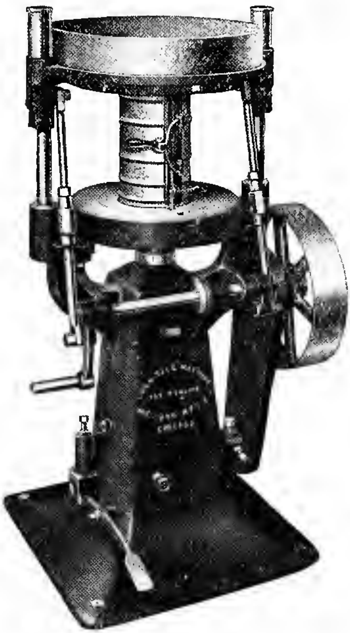
machine and revolved by power. The up-and-down motion of the packer, however, is controlled by a foot lever so that the packing is entirely under control of the operator. On the smaller sizes of tile it can be operated with 2½ horse power. The manufacturers, however, advise an engine of 3½ or 4 horse power in order to have it available for all sizes. In 3 to 6 inch diameters, manufacturers claim an average output of from 1,500 to 2,200 per day, while on larger sizes the capacity would be approximately 1,000 to 1,200.

The same firm also makes Crescent molds for drain tile and sewer pipe. The Crescent mold is very simple in construction, consisting of an iron pallet, an outer hinged shell, a collapsible core and cap for same, and a tamper. To these must be added the bell former for bell-end tile.

The outside casing and the core are of heavy sheet steel, reinforced at the top with angle steel to avoid all possibility of getting out of shape in the process of molding. At the lower ends they are held in place by the pallet, which is a circle of cast iron fitting accurately between the core and outer shell. This latter is made in two parts, hinged together with patented lock hinges which can be fastened during the process of molding, in such a way as to maintain complete rigidity, at the same time allowing the mold to be opened at once without in any way injuring the tile. Locks are of course provided also on the front of the mold where the two parts come together. The core, as stated, is made of sheet steel, which is curved into shape in such a way that the edges work past each other. In a state of repose the core is somewhat smaller than its working size. By a simple and easily operated device it is expanded and locked in place for working. The lock is released by reversing the lever, the elasticity of the steel collapsing the core sufficiently to allow it to be withdrawn.

Dunn Concrete Drain Tile Machine. This machine is manufactured by W. E. Dunn Manufacturing Company, Chicago, Ill. It is a small, compact machine at low price, built entirely without overhead mechanism. It consists essentially of a table resting on top of a cast iron standard, this standard enclosing the principal part of the actuating mechanism, and from which the packer shaft protrudes. This table carries the tile casing and a framework above, holding it in place. This frame is raised and lowered by a crank, as shown in the illustration, and the mechanism which operates the packer is started and stopped by a foot release. It makes tile 12 inches in length and in diameter from 3 to 12 inches. Every precaution is taken to make oil cups and bearings air-tight and dust-proof. The height of the machine is 48 inches and it occupies floor space 24 inches square. The upward motion of the tamper can be varied by changing the sprocket wheel, shown in the lower part of the machine. The packer revolves at a speed ordinarily of 125 revolutions per

minute. The claim of manufacturer is that this machine will make 1,800 to 2,000 tile pėr day with two men operating. A 5 H. P. engine or motor is recommended for operating the machine.



DUNN TILE MACHINE.

This company also makes hand molds for manufacturing various sizes of drain tile and sewer pipe, either with plain or socket ends.

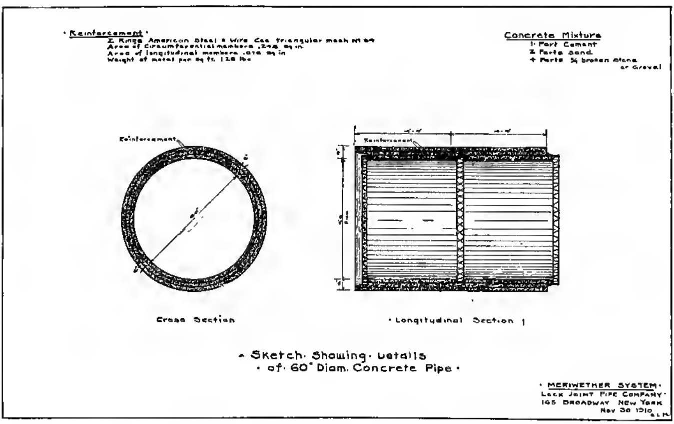
"Easy" Hand Molds for Large Sizes. These molds are made by the Cement Tile Machinery Company, Waterloo, Iowa. The core is made in three parts, which are quickly put together and as quickly collapsed. This core has an ingenious fastening device on the inside, which, when sprung open, will allow one to quickly take out the core in three parts without the danger of disturbing the newly made tile.

The outside casing is made in two equal parts and has a lever which unfastens both upper and lower hook at the same time and one-half of casing is removed and the the other. In this way there is no danger of knocking down the newly made product.

The molds are made of heavy galvanized steel, reinforced with channel iron in such a way that the molds never get out of shape.

Farmers Tile Machine. A small, portable machine with a daily capacity of 1,200 tile, made by the Farmers Cement Tile Machine Company, St. Johns, Mich.

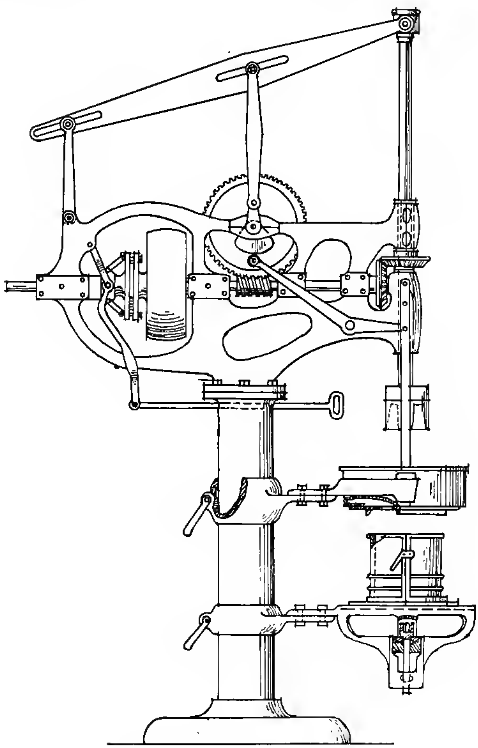
Lock Joint System. This system is designed for the manufacture of large sizes of reinforced concrete pipe, and is controlled by the Lock Joint Pipe Company, 165 Broadway, New York. Molds are made for pipe by this system in diameters from 24 to 96 inches, and in 4 foot lengths. The reinforcing used is wire mesh, expanded metal, or deformed bars, as required to give pipe of any desired strength. This pipe has a bell and spigot



Sketch Showing Details of 60" Diam. Concrete Pipe

joint, the bell being flush with the circumference of the pipe. The reinforcing metal extends throughout the length of the section and projects both into the bell end and out of the spigot end for several inches. The spigot

is shorter than the bell, so that when two sections of the pipe are placed together the reinforcing metal from one section overlaps the reinforcement of the other section in an internal recess. The recess in this joint is filled with cement mortar, thus locking the section together and sealing the joint at one operation. On all pipe of 36 inches in diameter, or larger, the joints are made from the interior after the back filling has been placed, by forcing grout behind a shield with a grout gun. On sizes less than 36 inches in diameter the joints are made from the outside through openings in the crown portion of the bells before the back filling is placed.



MONARCH TILE MACHINE.

Monarch Tile Machine. This machine is manufactured by the Monarch Manufacturing Co., Onawa, Iowa. It is a machine of the revolving packer type, and is built up around a simple cast iron standard. The cement hopper and bottom pallet are locked to this standard by adjustable locks so that they can be quickly placed in any position desired. The packer head is guided and supported in its working stroke through the jackets by an auxiliary shaft. This shaft fastens on the packer head and follows it on the upward stroke to a point where the packer head enters the double pallet, when it is released and drops back to its original position, allowing the jacket to be removed. Ball bearings are introduced at points where necessary. The machine is so constructed that the speed can be reduced and the power increased when making larg tile. It will make all sizes from 4 to 18 inches in diameter and in length of 16¼, 18¼ and 21¼ inches. This machine is also equipped for the making of blocks, porch columns, bases, etc.

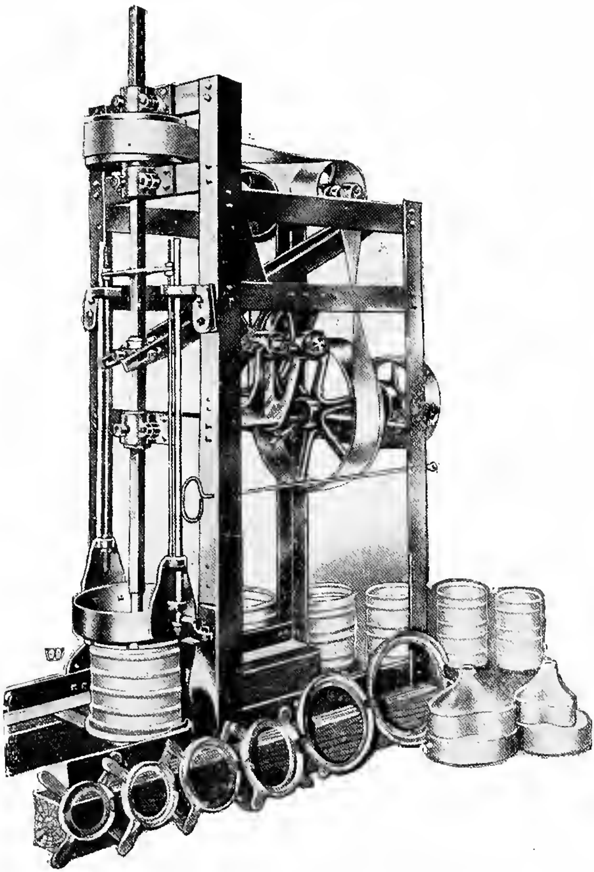
McCracken Tile Machine. Made by the Sioux City Cement Machinery Company, Sioux City, Iowa. An automatic power machine, making tile from 4 to 18 inches in diameter, and 12 and 18 inches in length. Also has an attachment to make tongue-and-groove pipe for sewer and irrigation work. The popular style of this machine, known as the McCracken Junior, is a compact piece of mechanism occupying small floor space. It is a machine of the revolving packer type, the packer descending into the mold, this latter being carried by a sliding table. The feed is automatic.

This machine will also make standard size building blocks of various designs.

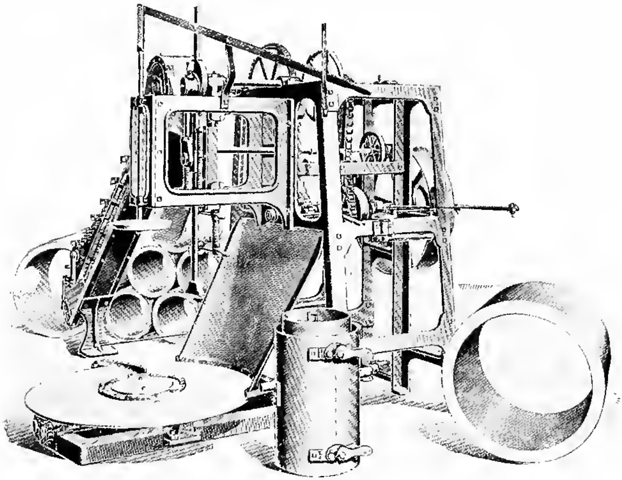
The McCracken machine is also made with double head if desired.

National Cement Tile Machine. This machine is made by Quinn Wire & Iron Works, Boone, Iowa. It is intended especially for large sizes, making tile 14 to 32 inches in diameter and 2 feet in length. The distinctive

characteristics of this machine are a revolving plate which carries the mold, and a tamper which operates between the inner and outer sections of the mold. This tamper plays up and down like a trip hammer, ramming concrete in the mold, striking a 50 or 60 pound blow and running at a speed of 300 blows per minute. While this tamping is in progress the plate carrying the mold revolves stead-



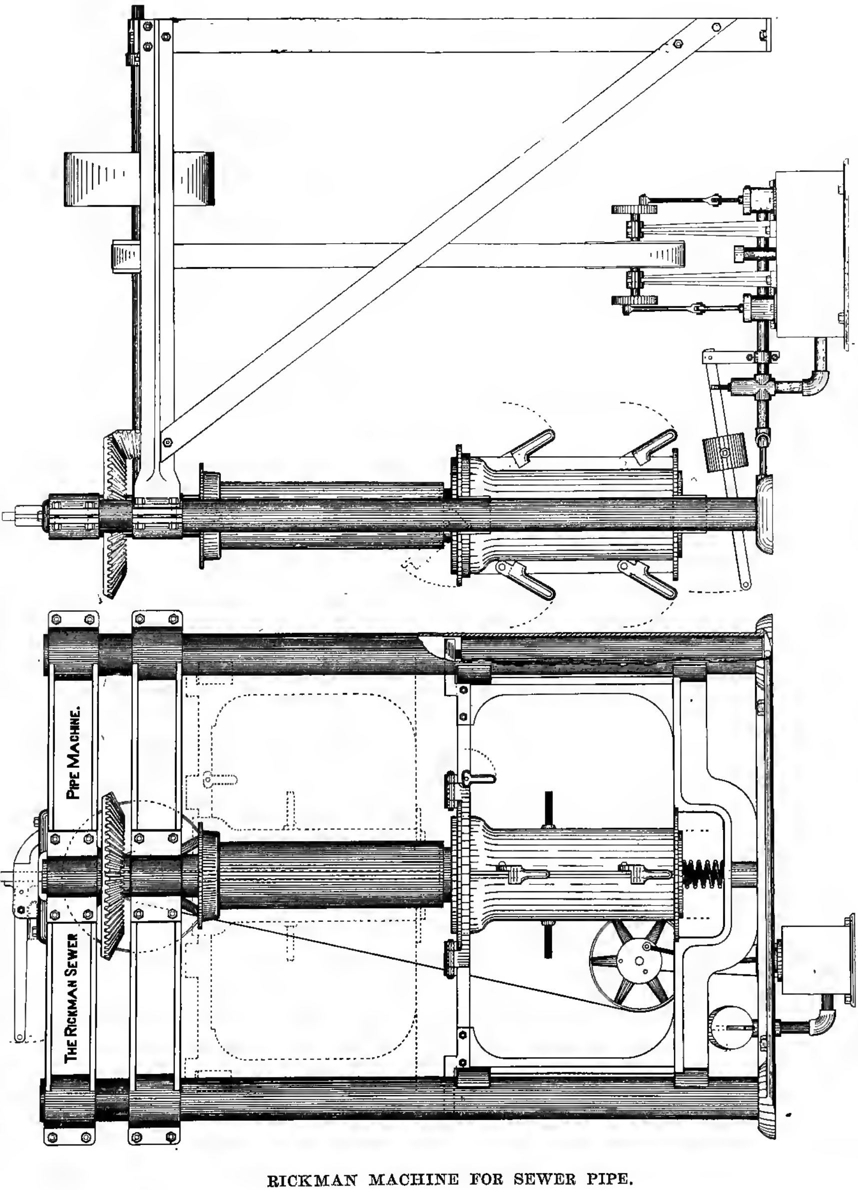
MCCRACKEN TILE MACHINE.



NATIONAL AUTOMATIC.

ily and the concrete is gradually discharged into the molds and tamped down hard. The frame of this machine is of heavy cast iron. The revolving table is of heavy steel and is revolved by two friction wheels under it. The outside mold is in two pieces, made of heavy sheet steel, and the inside mold of No. 10 sheet steel and made in one piece. The larger sizes of tile when finished are carried away by a special truck, this truck picking them up by handles provided on the sides. The machine can be operated by two men, though it requires five men to work it to its full capacity. The capacity given by the manufacturer is 600 feet of 14 inch pipe in 10 hours and from that down, varying according to the size, to 250 feet of 32 inch pipe in 10 hours. This machine, together with a small mixer, can be operated, it is claimed, by an engine of 4 horse power. This machine is also made with a double working head, allowing two tile to be made at a time on sizes up to 20 inches, thus doubling its capacity.

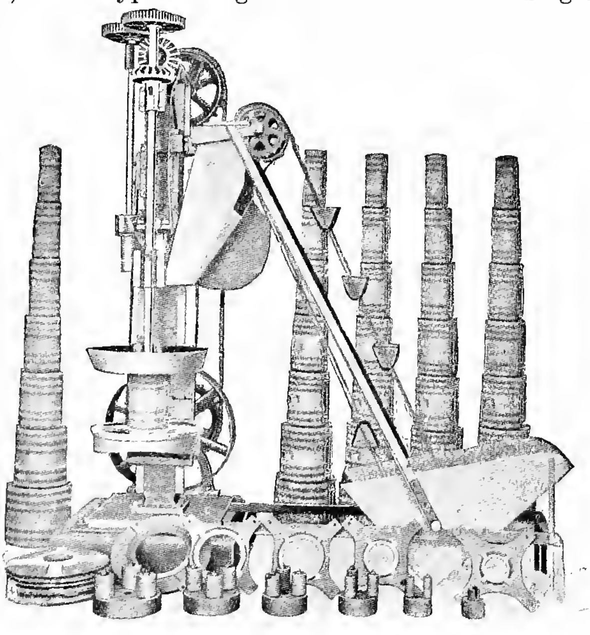
Rickman Sewer Pipe Machine. This machine was designed and is manufactured by R. L. Rickman, Eau



RICKMAN MACHINE FOR SEWER PIPE.

Claire, Wis., its purpose being the manufacture of bell end sewer pipe. As will be noted from the drawings, it has as a main frame a tubular steel standard held in place by an auxiliary frame of angle steel, this auxiliary frame carrying the line shaft and the entire machine occupying a floor space of 5x6 feet, and 86 inches high. The two upright standards carry a table and frame mounted on plungers and operated up and down by an oil pump. This frame carries the sewer pipe mold, the action of the oil pump carrying it up to the position as shown by the dotted line, bringing the mold with its load of concrete around the revolving packer. The machine makes bell end pipe, 4 to 12 inches in diameter and 2 feet in length.

Rosbrugh Tile Machine. The Rosbrugh cement tile machine, made by the Nappanee Iron Works, Nappanee, Ind., is the type having for its main frame a single cast



ROSBRUGH TILE MACHINE.

iron standard. It is made in two sizes, one for tile 12 inches long and from 4 to 12 inches in diameter, and the No. 2 size for tile from 4 to 18 inches in diameter, each 12 or 18 inches long.

The table carries a single jacket and moves up and down around the packer head, this latter remaining stationary. It has conveying buckets, which are automatically timed and carrying the requisite amount of material for each size of tile.

The movement of the table is so adjusted as to give it a dwell at each end of the tile, which is intended to make the ends very hard. After the packing of the tile is completed, the table drops to a point 6 inches farther down, where it remains motionless for a sufficient period of time to allow the tile to be removed and an empty jacket put in its place.

The manufacturers claim that two men can operate the machine and make from 1,200 to 1,500 tile per day. With a car system and sufficient men, this output can be very largely increased.

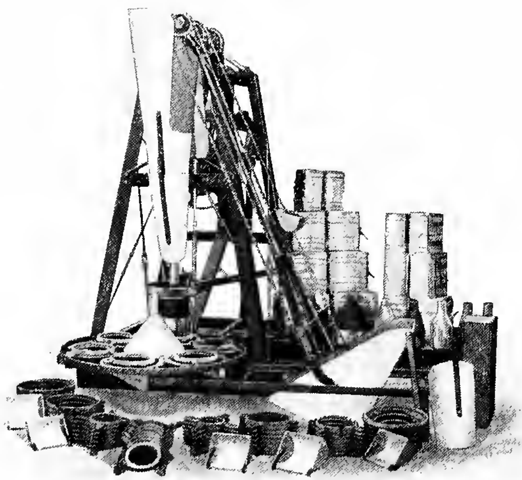
Schenk Cement Drain Tile Machine. This machine is manufactured by the Cement Tile Machinery Company, Waterloo, Iowa. It consists essentially of a pyramidal frame about 8 feet high, a revolving table for carrying the molds, a revolving shaft carrying the packet head, a boot from which the molds are filled, and a bucket elevator which delivers concrete to the boot.

The tile are made in galvanized iron jackets, made in two parts, and provided with hinges and lock. These jackets set on pallets carried by the revolving table, the table carrying six pallets of any size. These pallets are held by pins in the table, the change from one size to another being made by simply lifting off one set of pallets and dropping another into place.

The table is revolved and the jacket placed in a position for making tile by means of a cam at the rear of the machine. There is a ring, or rather a combination ring and a small hopper, which drops down on to the jacket

after it is revolved into position, and holds the jacket solidly in position while the tile is being made.

When the jacket is in place, the packer head, which is on a sliding shaft, operated by another cam at the rear of the machine, drops down through the jacket and into and fills the bottom ring; and just at this point, where the packer fills the ring, the concrete is dumped in from the top by means of the elevator. The cup on the elevator holds just enough material to make a tile, different cups being put on for the different sizes. Thus the concrete is



SCHENK TILE MACHINE.

dumped down inside of the jacket and around the packer, and the packer head revolves up through the concrete and packs, forces and presses the material between the jacket and the packer. This packer head has concave sides and is graduated out from the size of shaft on which it revolves, to the full size of the inside of the tile at the lower end. Thus, it is in one sense the core, for it forms the inside of the tile, and revolves up out of the jacket through the top ring, and the ring rises with it and re-

leases the jacket, and the tile is made; then the table revolves and another jacket moves into place.

This machine is now made in several sizes and styles, with ranges from 4 to 18 inches in diameter, 12¼ and 18 inches long, and in sizes and prices to meet the needs of both large and small manufacturers.

Thomas Machine for Bell-end Sewer Pipe. A machine for the manufacture of glazed bell-end sewer pipe is the invention of Mr. James Thomas of Seattle, Wash.

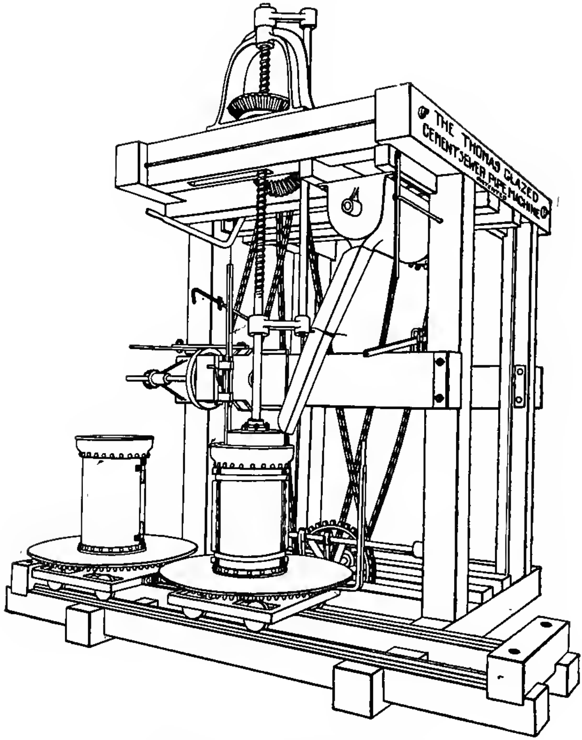
The principles upon which this machine has been developed include automatic troweling and tamping; the troweling produces the interior glaze, and the automatic tamping uniform density and homogeneous texture. The trowel effect is brought about by a stationary core of polished steel and a potter's wheel; the automatic regulation of the tamping is one of the unique features of the machine.

The machine occupies a ground space 17x10 feet, and is 7 feet 10 inches high. Each machine is a double header, that is, it is built for the manufacture of two pieces of pipe at the same time; usually the ends are constructed to accommodate different molds, one for the smaller and one for the larger sizes.

An overhead shaft operates the feed and the stem of the core; an underneath shaft operates the tables, and all of these movements are controlled by levers which are handy to the machine man.

Sunken tracks at each end of the machine support a carriage with two tables, or potter's wheels. One of the tables is in operation making pipe, while the other is being relieved of its pipe and an empty mold put in place. The tables are 36 inches in diameter, bored with a series of concentric lug holes, which provide an easy means of shifting from one size of pipe to another Pipe may thus be readily made in any of the standard sizes from 4 to 30 inches in diameter. The molds are made of steel and fitted on the outside with toes to engage the lugs in the wheel and thus made to revolve with it.

The table has a four-fold function: distributing the

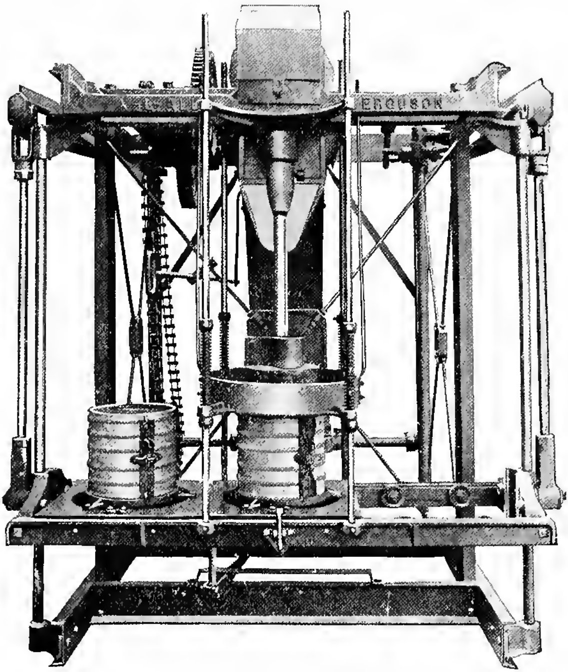


THOMAS SEWER PIPE MACHINE.

feed, equalizing the tamping, troweling the inside of the pipe, and assisting in the discharge of the core, all of which is accomplished while the table is in motion.

X-L-All Tile Machines. The X-L-All Manufacturing Company, 21 South Clinton Street, Chicago, makes two tile machines, known as the X-L-All Ferguson and the X-L-All Junior. Both of these are of the revolving packer type. The Ferguson machine has a stationary packer, so far as up-and-down motion is concerned, this motion being taken by the frame carrying the table on which the molds rest. This table carries two molds and shifts automatically when the table reaches

its lowest point. It will make tile in either 12 or 18-inch lengths and in diameters from 4 to 16 inches. It can be operated by crews of from four to eight men, at a stated output of from 3,000 to 5,000 per day. The X-L-All



X-L-ALL FERGUSON.

Junior is a much smaller and simpler machine, but operating on the same general principle. It has no sliding table, thus carrying only one mold, and has no elevator to fill the jackets. It makes only the 12-inch length, 4 to 12 inches in diameter and with three or four men will produce 2,000 to 2,500 tile per day.

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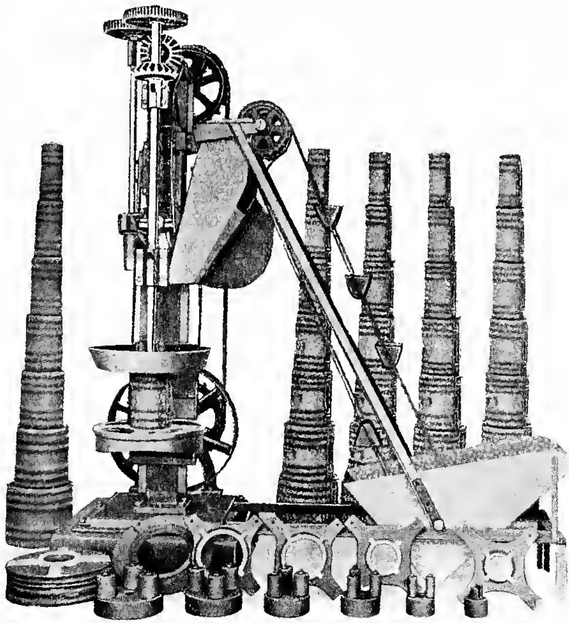
THE ROSBRUGH
CEMENT TILE MACHINE



WORKS LIKE A CLOCK

Once started it works continuously; no stopping or starting required for removing and replacing of jackets; requires but little attention.

The ROSBRUGH is free from vibration. This is but one of the many features that eliminates all uncertainties from the manufacture. It is compact, durable, economical and easily operated. There are no complicated parts to cause delay and expense. Every part is built to withstand wear.

The ROSBRUGH No. 1 is equipped to build tile 4, 5, 6, 7, 8, 10, 12 in. in diameter, 12 in. long.

The ROSBRUGH No. 2 is equipped to build tile 4, 5, 6, 7, 8, 10, 12, 14, 16, 18 in. in diameter, 12 and 18 in. long.

FURTHER INFORMATION ON REQUEST

THE NAPPANEE IRON WORKS

NAPPANEE, IND.

(An illustration of this machine appears on page 145.)